A STEP-BY-STEP, ILLUSTRATED GUIDE FROM THE EXPERTS AT MAXIMUMPC

PC HOW-TO GUIDE

BUILD AN *AMAZING* PC NOW!

- Master the art of hard pipe water cooling PG. 42
- Get incredible gaming performance for free PG. 19
- Create a micro-sized 4K-capable machine PG. 54
- Experience a pulse-pounding racing rig PG. 28
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Volume 02 2016

Future

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Alex Cox

WELCOME

AREN'T PCS BRILLIANT? The answer, reader, is yes. As if you didn't already know that. And how far we've come since the beige box, the five-and-a-quarter-inch floppy, and so few pixels of lurid four-color CGA that you could count them on your fingers. Today's PC is a quantum leap away. But you know what? I think the PC is only just beginning its rise.

Virtual Reality – let's not get into just how far *that's* come – is the PC's killer app. It's still in its infancy, but it's going to grow into one hell of an adult. And for every tentative step consoles take towards being able to throw trillions of pixels at each of your eyeballs, the PC will always be a step ahead, riding on upgrades and pushing pixels faster with every small investment. What's more, the PC is, as we shall prove, entirely competitive on price. Over on page 6 *Maximum PC*'s expert assembler Zak 'Scuffed Knuckles' Storey does the improbable, putting together an absolutely killer VR rig for under 700 bucks. Completely absurd.

That's not all, of course. I've pulled in a whole stack of Zak's other ridiculous builds, pushing out 4K (page 54), absolute top-end rendering power (page 62) and much more. Pay particular attention to his bang-on guide to hard pipe water cooling on page 42, an absolute must if you're building a power rig and want it cool, quiet and knockout gorgeous.

Can't let Zak have all the fun, though. Top journo, reckless driver and PC component expert Jeremy 'Cars' Laird has been coaxed out of his European roadster long enough to lock himself in his basement and set up a masterful driving game setup (page 28) complete with projector, bucket seat and, presumably, a little air freshener in the shape of a tree. Then industry insider Dan 'Information' Griliopoulos flexes his contact book and research acumen to investigate the standing desk phenomenon; it's doubtful you'll be banging out rounds of Overwatch while on your feet, but it could make your working life better and your life longer.

All that's just the tip of the iceberg. *Maximum PC*'s genius crew will also teach you how to make Windows faster and slightly less broken, how to keep backups in case your incessant tinkering leaves your drives fried, how to kick your graphics into overdrive, and much more.

So, all that's left is for me to congratulate you on being a PC enthusiast clever enough to pick up this special issue – you're the best, really – and to suggest that if you like what you see here, a subscription to *Maximum PC* magazine is the best way to get more of it. Head to page 40, sign up, and get the best PC builds, guides, buying advice and features delivered direct to your door way before the mag hits the newsstands.

Alex Cox is a contributing editor to Maximum PC*, and he's currently up to his elbows in thermal paste. Don't ask how it happened. It's a long story.*

↘ submit your questions to: comments@maximumpc.com

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Build a Budget VR-Ready PC

AMD's RX 480's VR claims are put to the test in a $699 rig

BY ZAK STOREY

VIRTUAL REALITY: two words on the tip of the tongue of every tech journalist this side of the Pacific. And with good reason: As far as technological advances go, this is the biggest development in screen technology we've seen since CRT was retired in favor of LCD. But there's one caveat, and it's a big one: the price. It's a heavy commitment—$800 for a headset, and $1,400 or more for a rig capable of powering it. Is it any wonder why we—and the critics—are holding our breath on this one?

What does VR need? In short, more uptake and a lower price point. We now know that there are over 40 separate headsets currently making their way to market, including more affordable—yet still high quality—products from the likes of DeePoon and other manufacturers. This is a huge leap forward, as far as media development is concerned, because it will encourage game developers to create titles specifically for VR, thanks to the increasing user base. So, that just leaves the system....

Let's say, hypothetically speaking, of course, that we're likely to see a headset in the region of $350—could we potentially game comfortably with VR for a little over $1,000 in total? That's what we're hoping to prove with this little build. Centered around AMD's latest 14nm GPU and a budget FX system, we're taking a look at exactly how you would go about building a virtual reality system on a budget.

INGREDIENTS

PART		PRICE
CPU	AMD FX-8320E	$119
CPU Cooler	Cooler Master Hyper 212 EVO	$25
Motherboard	MSI 970 Gaming ATX AM3+	$76
RAM	Corsair Vengeance Pro 16GB (2x 8GB) DDR3 1866 MT/s	$68
OS Storage	Kingston SSDNow V300 Series 120GB 2.5-inch SSD	$39
AD Storage	Hitachi Ultrastar 1TB 7,200rpm HDD	$43
GPU	AMD Radeon RX 480 8GB	$240
Case	BitFenix Neos Black/Red mid-tower ATX	$44
PSU	EVGA 600B 600W PSU (Bronze)	$45
TOTAL		$699

Prices correct at the time of going to press.

MSI
MSI 970 GAMING
Kingston
120GB
CORSAIR
VENGEANCE
CORSAIR
VENGEANCE

CPU

AMD FX-8320E

$119

Historically, AMD has always been the go-to company for budget builds and cheap CPUs. Recently, however, AMD has put more time and effort into developing its Kaveri line. Although boasting relatively impressive integrated graphics, Kaveri lacks a great deal of computational power, enabling Intel to dominate the scene. That said, you can still find yourself a solid AMD gaming CPU, just as long as you're willing to give up native USB 3.0, PCIe 3.0, and additional SATA 6Gb/s functionality for the sake of your budget.

For this build, we settled on an FX-8320E. Despite being an ageing processor, this little beauty's eight cores should be more than enough to drive the latest games at 1080p and beyond. And if DX12's multi-core-loving features are anything to go by, this CPU should be able to pump out some impressive benchmarks later on in its lifetime. The chip comes in at $119, featuring eight cores, running on a base clock of 3.2GHz (turboing up to 4GHz), and offering up support for DDR3 memory up to 2,400MHz on the AM3+ socket. Although not the tsunami of rendering power that you'd find on an Intel chip, the CPU performs admirably for everyday computational tasks.

The alternative solution from Intel would be the Core i5-4460 (it's a budget-friendly Haswell chip.) Its four cores provide very similar performance, but it isn't overclockable, meaning you won't be able to increase those numbers any time soon. Despite this, it does provide PCIe 3.0, more SATA 6Gb/s ports, and native USB 3.0 support, giving it the slight edge when it comes to the feature set.

GPU

AMD RADEON RX 480 $240

AMD's Radeon RX 480 ruffled some feathers on its way to the top of the value pile. It's a 14nm FinFET card utilizing a single six-pin connector, which at launch saw it drawing more power than the specifications allowed for. A quick driver update sorted this out though, with a nominal drop in performance equating to less than a frame on average in our benchmarks. So all good? We can't help wondering why AMD didn't double-check this on launch, but no real damage done.

That debacle aside, the RX 480 is a stunning card. At the time of writing, it has no equal when it comes to the price to performance ratio. Not even the GeForce GTX 1060 troubles it.

But the real money earner is what AMD is including in the GCN 4.0 architecture. It primarily comes down to a nifty piece of logic embedded into version 4.0, known as Asynchronous Compute with Quick Response Queue, which enables the developer to tell the GPU when to complete a compute task ahead of a graphical one, as opposed to the GPU deciding off the cuff. This is crucial for VR, because it will ultimately reduce latency lag, and that notorious nausea.

RAM

CORSAIR VENGEANCE PRO 16GB $68

Memory selection is always slightly controversial. Frequency tends to increase alongside latency, so increasing overclocks actually provides very little in terms of an overall performance increase.

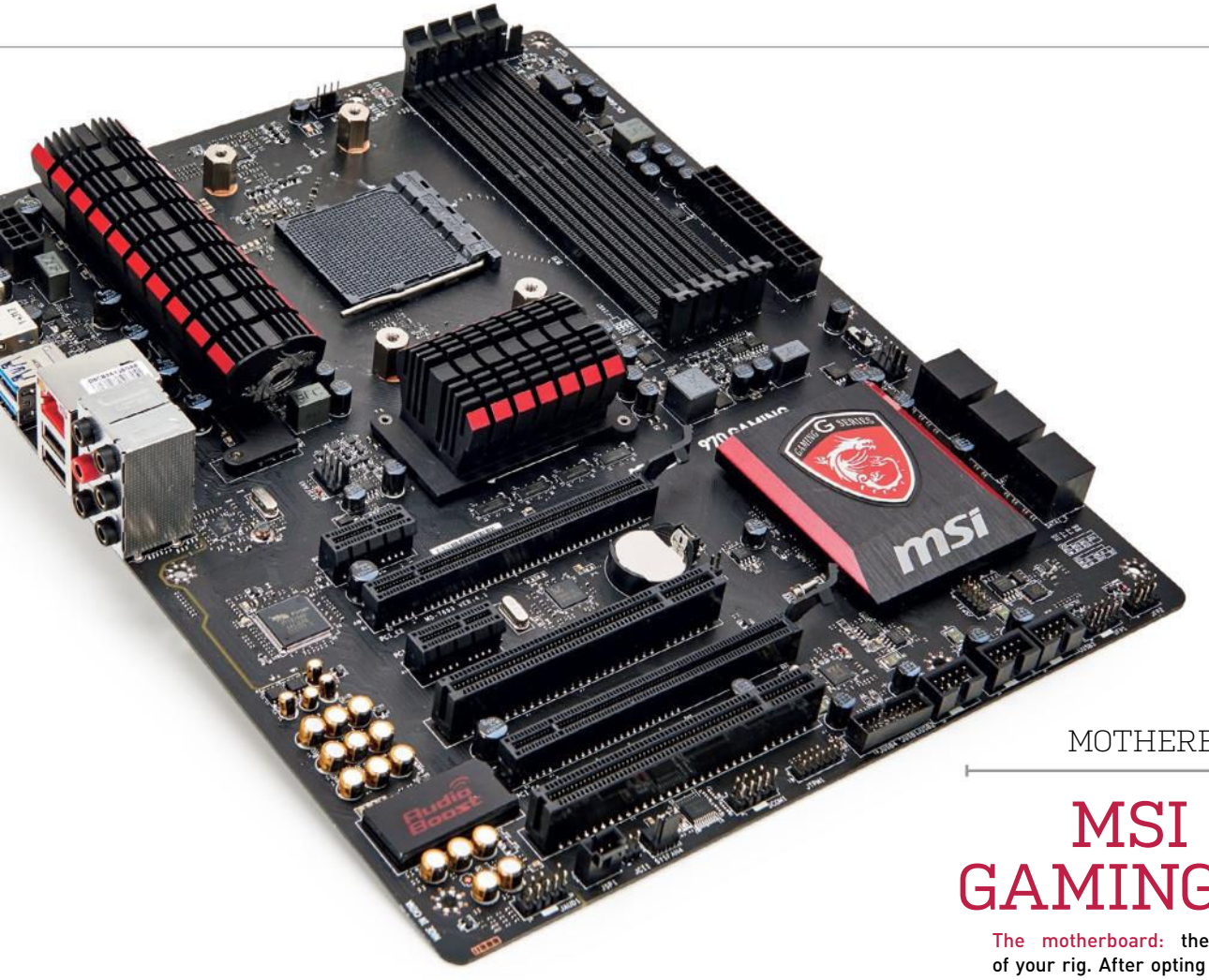
That said, the biggest winner is capacity, and although the FX-8320E at the heart of this little build is hardly the renderer of tomorrow, we opted to go for 16GB of Corsair Vengeance Pro DDR3 memory at 1,866MT/s. That way, there's absolutely no chance of the RAM being the bottleneck, and in theory, we do have the opportunity to upgrade to a Skylake B150 platform later on, without losing much in the way of performance, outside of power savings.

CPU COOLER

COOLER MASTER HYPER 212 EVO $25

Let's be realistic here. The FX-8320E is not a super-fast core, certainly not at stock. So, if we can overclock it, we will. And, quite frankly, even at stock, the retail cooler that AMD ships with the eight-core processor doesn't cope very well with heat. At all. So, with what little budget we had left, we decided to invest in a CPU heatsink worthy of our effort.

Ladies and gents, we give you the Cooler Master Hyper 212 EVO. It's not the best-looking heatsink out there, and it's not the most intuitive to put together. But is it solid and dependable? Yes. Will it keep your beans on ice? Well, probably not. But if you're looking for room temperature, it'll do just fine.



MOTHERBOARD

MSI 970 GAMING $76

The motherboard: the backbone of your rig. After opting for the FX-8320E, we had to find a suitable solution to house all that power. Unfortunately, finding new mobos in AMD's lineup is quite a challenge. It's certainly less simple than with Intel, where each new chip denotes a new chipset.

The MSI 970 Gaming is a fantastic entry-level gaming motherboard. Featuring support for CrossFire and SLI, as well as DDR3 up to 2,133MHz, and a plethora of SATA connectors (at least, for an AMD board), there's no better choice. And guess what! It's black and red.

OS STORAGE

KINGSTON SSDNOW V3 120GB $39

You shouldn't even bother calling yourself a PC enthusiast today if you're not using an SSD for your operating system. The price of flash storage has plummeted over the last couple of years, to the point where you can buy yourself a 120GB Kingston SSDNow V3 for $40. Granted, it'll run a little slower than some of the more premium options out there, but it's a damn sight faster than any HDD, that's for sure.

For additional storage, we threw in a 1TB Hitachi Ultrastar 7,200rpm HDD ($43). This will provide you with plenty of space for all of your games and any additional files you might need to store on your budget build.

CASE

BITFENIX NEOS BLACK/RED

$44

With a $700 budget, it's inevitable that your spec is going to take a hit somewhere. More often than not, this is in the chassis department. For us, the choice was obvious. BitFenix does some fantastic, good-looking, and value-oriented case options. And the BitFenix Neos comes in at just $44, putting us well within our target budget.

This cheap and cheerful chassis is a small, lightweight, and stylish ATX mid-tower. Ideal for our build, it also includes some very intuitive features that you'd not expect to find on a case with such a low price point, such as 2.5-inch and 3.5-inch removable drive bays, the latter of which are tool-less. Additionally, if you fancy chipping in a little extra, you can drop another $10 on the windowed edition, which nets you a red LED BitFenix Spectre fan as well.

PSU

EVGA 600W BRONZE $45

The power supply will always be one of the trickiest components to choose when it comes to building your first rig. The biggest challenge is finding out how much wattage your lovely new PC is going to utilize, and then allowing for that. Your best bet is to use a calculator. You'll find a fantastic integrated PSU calculator at the top of your selected parts' list at www.pcpartpicker.com.

Ideally, the PSU is one of the components into which you should invest as much as you can. In short, if you buy too cheap a power supply, and it pops, it could easily take one or all of your components with it. Because of this, and our tight budget, we opted for an EVGA 600+ Bronze. Unfortunately, it's non-modular, but it does give us 600W of power and a bronze efficiency rating, which should be more than enough for our AMD build.

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Time to Get Building

A step-by-step guide to putting your VR-ready PC together

1

PREP FOR YOUR BUILD

IT'LL PROBABLY come as no surprise, but the best way to build a rig is to plan it well. The first and most crucial aspect of creating your new PC is setting up your build area. Make sure that wherever you decide to construct your machine, the area is free from distraction. Ensure you have all the tools you'll need to put your wee beastie together (usually a Phillips screwdriver, some scissors, and a set of needle-nose pliers for the fiddly bits). And, last but not least, try to find a static-free area—avoiding woolly socks and carpets is usually best.

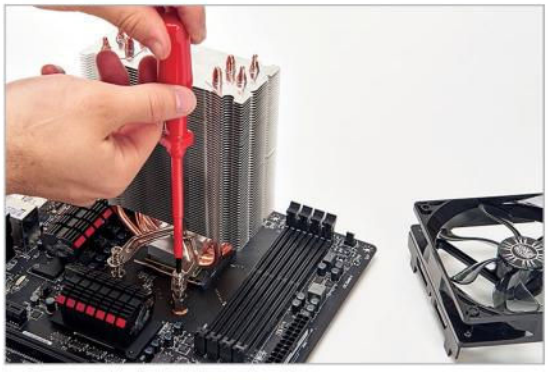
If you're paranoid, you can buy an anti-static strap, but if you can't find one, or are feeling stingy, ensure you regularly touch the casing around a power supply that's plugged into the wall, but powered off. This discharges all the static electricity that you're potentially building up in your body, and may possibly save yourself some heartache later.

2

INSTALL THE CPU AND HEATSINK

START BY BUILDING your PC outside of the case. If any components are dead, it makes it much easier to diagnose and disassemble. The mobo box also acts as a great anti-static test bench. Start with the CPU. Lift the retention arm on the CPU socket on the mobo, and align the FX-8320E with the socket (the golden triangle on one corner of the CPU should match up with the same triangle on the socket). Drop it into place, lower the arm back down, and lock it in.

Now, the heatsink. Secure the backplate with the nuts and bolts. Add a dollop of thermal paste to the middle of the CPU, then carefully position and screw down the heatsink, ensuring the intake of the fan faces the base of the case. Screw the heatsink down in a cross pattern, so you don't put excess pressure on one side of the CPU, potentially bending the pins. Then loop your CPU fan cable around, and plug it into the CPU fan header located above.



3 ADD THE RAM AND GPU

NEXT IS THE MEMORY. Lift the tabs on either side of the DIMM slots, then line up the RAM, matching the gap in the stick to the notch in the mobo. Push it securely into place. Once you hear a satisfying click, you'll know it's correctly seated. It doesn't really matter which channels you use, but for maximum performance, it's often best to place them one apart (usually color co-ordinated). Also, for this build, you'll want to place them as far away from the heatsink as possible, due to the size of the cooler, while still keeping them in the color co-ordinated channels.

After this comes the graphics card. Gently take your GPU out of its anti-static bag (don't place it on the outside of the bag, as it's conductive, and will discharge all the electricity it's collected). Remove the protective covers on the PCIe connector on the bottom of the card, and gently slot it into the top-most PCIe slot. Usually, we'd advise you not to touch the PCB on the back of the card, but depending on which graphics card you actually use, this may be hidden by a backplate anyway.

4 ATTACH THE MOBO

ONCE YOU'RE CONFIDENT that your new gaming hardware is working, it's time to throw this bad boy into your chassis. First, pull the GPU out of your mobo (simply move the clip located on the PCIe slot upward). Next, unpack your case and remove all the unnecessary components. This means two of the SSD trays can come out, plus two HDD trays, and the little welcome pack of screws. After this, take the rear I/O shield out of your mobo box, and place it into the rear of your case (make sure it's oriented the right way round), and push it into the slot at the back of the chassis, until it clicks into place along the edges.

Next, align your mobo with the pre-installed standoffs, and screw it down. Remove the two corresponding PCIe slot covers on the back of the case, and reinstall your GPU, before securing it with an extra two screws. You'll have to remove BitFenix's ingenious PCIe slot cover—just pull it out, then click it back into place once you're done.

5 PSU AND CABLE MANAGEMENT

NOW FOR THE POWER SUPPLY. Remove the case's side panels, and slide your PSU into the allocated rear slot. Make sure the fan's facing down, so it can pull air from the underside of the case and exhaust it out the back. Push all of the cables through the space in the bottom of the case.

You'll want to plan which cables go where. The CPU's eight-phase power is hardest—pull it up through the uppermost hole. Run it along the top of the mobo, around the RAM, and into the CPU power. The 24-pin power for your mobo can go in the cable-routing hole below the one you've just used for the CPU. Don't force anything, as you'll risk damaging the connector and power supply cable. Then route your front I/O cables around the back, and down into the bottom half of the chassis. Refer to the manual to connect your power/reset buttons and LEDs.

Next, leave three SATA connectors in the rear, and the PCIe power cables in the front. Bundle the remaining cables together with ties, and leave them in the bottom of your chassis.

6 INSTALL THE SSD AND HDD

IT'S NOW TIME to install your hard drives. The BitFenix Neos comes with both 3.5-inch and 2.5-inch drive bays. To install SSDs, pull one of the 2.5-inch drive trays out. Place your SSD inside it (with the connectors facing away from the two finger grips), then secure the drive in place with four screws. Once it's snug, slide the drive back into the cage until it clicks. For the 3.5-inch hard drives, BitFenix has developed an innovative way to secure them. Simply take one of the drive caddies, pull it gently apart, slot the drive in place, and push the caddy back together. Again, with the connectors facing away from the two finger grips.

Now run two SATA cables from the first two ports on the mobo to your drives. Avoid the cable holes, and run them past that panel, around the back of the chassis. Due to the position of the cutout, you won't be able to run the cable through the hole. Then connect the two hard drives using the SATA power connectors we left behind the case earlier.

7 RESEAT THE GPU

NEXT UP, you'll want to reseat the GPU again. Simply line it up once more with the PCIe slot, and press it firmly into place, without using too much force. Try not to bend the connector, or you'll end up snapping it off, and ruining not only your GPU, but your motherboard, too.

Then run the six-pin PCIe power connector to the card, and install it as you did previously. Additionally, you could use a cable tie here to make sure the PCIe power is nice and cosy. It isn't entirely necessary to cable-tie everything down, but it's always advisable to do it where you can, because it improves airflow and generally looks better. It's also a hell of a lot easier to see what you're doing if you need to make modifications in the future, or if you need to clean out your PC.

8 FRONT I/O CONNECTORS

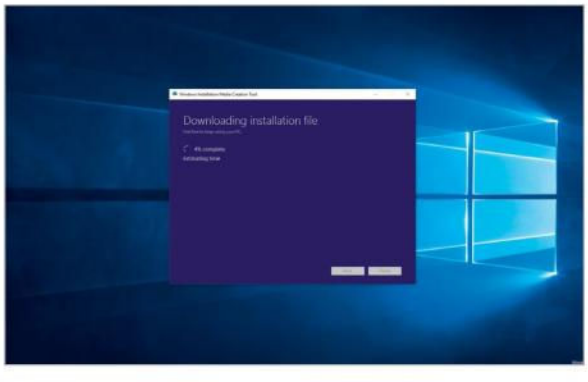
NOW FOR THE front I/O connectors. The cables should be positioned through the bottom of the chassis. Run the HD audio as far down as you can, along the bottom of the mobo, and into the HD audio connector on the bottom-left.

Next, grab the USB 3.0 cable, and do a similar run. The USB 3.0 connector is on the bottom-middle of the mobo. The USB 2.0 cable can be plugged into the right of the USB 3.0 cable. The front power and reset switches aren't labeled on the mobo, so refer to the manual for the correct positioning of each pin. Then secure the side panels back on the chassis.

9 INSTALL WINDOWS 10

WE'VE FOUND THAT the best way to install Windows 10 is via a fresh install using a USB stick. Get the ISO via your Microsoft account, then insert a USB stick (8GB is the usual minimum), and use Microsoft's Media Creation Tool to create a bootable disk. The USB stick will be formatted, so make sure any data on there is backed up.

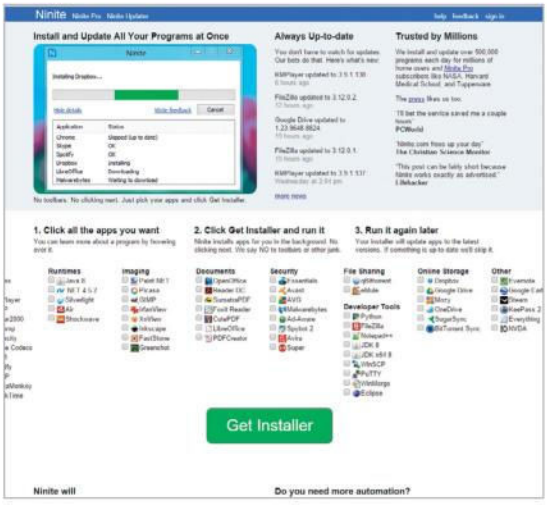
Once you've created your bootable media disk, plug it into a USB 2.0 port at the back of your PC. (If you're running Intel, you should plug it into USB 3.0.) Then boot your PC and make your way to the BIOS. Find the USB stick in the boot order lineup (top of your screen), and drag it to the far-left. Hit F10, save settings, and apply, and let your PC boot into Windows. Once in, you're going to want to jump on to another PC, laptop, or phone, head to http://bit.ly/1TljD0d, and download the Win 10 LAN drivers on to a USB stick. Install them on your rig, update the rest of your drivers, and voila—most of your work is done.



10 ADD PROGRAMS

A QUICK AND EASY way to install a lot of commonly used programs is a website called Ninite. It's incredibly straightforward, and something we use almost every day. Head to www.ninite.com, select which programs you want to install, and select "Get Installer."

Ninite then downloads its installer, and automatically installs those programs, ensuring you get the most up-to-date software available. Adware-free, no hidden secrets. (It makes money from a B2B product, so don't worry!) Then it's just a case of installing your more bespoke favorite programs, and you're good to go!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1 **The tool-less 3.5-inch bays make it incredibly easy to install any additional hard drives you might have, allowing for a total of three.**

2 **BitFenix even includes 5.25-inch tool-less bays. If you really do need an optical drive, you could throw one in here with relative ease.**

3 **A modular power supply would have been nice here, but the EVGA 600B is brilliant value, and comes with a great warranty.**

4 **The Neos also has support for two 120mm fans in the front of the chassis, which is ideal for a hot system, like this one.**

GAME ON

SO, WE COME TO the big question—the one on everyone's lips: Does this machine meet the VR-ready specification? Has the impossible been achieved? Has Polaris and the 14nm manufacturing process finally made budget VR possible? Can we keep asking rhetorical questions that you can't answer as a way of building the suspense?

The answer is yes, to all of them. Not by a foot, but by a mile. In Steam's VR Performance Test, our AMD budget build scored an absolutely astonishing 6.6, bringing it nicely into the green bar, well beyond the "capable" segment, and into VR-ready. And all for a touch less than $700, too. Apart from that, in-game performance was, relatively speaking, for the price, quite incredible. Both *Far Cry Primal* and *The Division* scored well into the fifties for average frame rate, and *Rise of the Tomb Raider* scored a respectable 35fps with everything ramped up—a title that's notorious for hammering down our frame rates in testing. What is interesting, though, is that despite AMD's continued development with DirectX 12, *ROTTR* actually averaged 4fps lower than DX11, indicating that Piledriver's low overall single-core performance may have something to do with it.

Computational performance, on the other hand, was a far sadder story. In CineBench, we saw a respectable 507 points, but taking a quick look at single-threaded performance saw an astronomically low 90 points, almost 100 points lower than last issue's Intel Core i5-6600K. On top of that, SSD performance was a little lackluster. Although the Kingston SSDNow V3's read speeds were well up at 511MB/s, the writes didn't fair so well, scoring 105MB/s

The overall build process was fairly smooth. Obviously, at this price point, it's never going to run completely smoothly—after all, we're talking about a $44 chassis and a non-modular PSU. Something to take note of is definitely a lack of length in the EPS power. It was quite a squeeze to thread it through the back of the chassis, then up, and in—you could potentially get around this by using an extender, but then it's a case of breaking the budget a fraction more. Also, the Cooler Master Hyper 212 Evo CPU heatsink, once configured correctly, was an absolute pain. Not particularly difficult to install, just annoying.

Ultimately, this system is ideal for those looking to build themselves a nice little niche gaming PC, solely to be used at 1080p, and for general office work. It's not a rendering powerhouse, or some monster of solid-state performance, but a perfect gaming rig.

BENCHMARKS

CineBench R15 Single	90
CineBench R15 Multi	507
TechARP x264	11.98fps
CrystalDisk Sequential Read	511MB/s
CrystalDisk Sequential Write	105MB/s
CrystalDisk Random 4K Read	21.94MB/s
CrystalDisk Random 4K Write	83.66MB/s
PCMark 8 Creative (Accelerated)	5,380
3DMark Fire Strike	7,835
Rise of the Tomb Raider	35fps
Far Cry Primal	53fps
The Division	57fps

All games are tested on the ultra preset, with HD texture packages, and antialiasing set to the maximum possible. All frame rates are averages.

BUDGET VR BENCHMARKS

	AMD Budget Build	Zero-Point Machine
Steam VR Performance Test	6.6	**9.6**
Price	**$699**	$2,275

Zero-point machine based on cheapest possible configuration. Best scores in bold.

Windows 10

AMD

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Cortana available in select markets at launch, experience may vary by device.

*External monitor must support HDMI input (If continuum-compatible accessory is not included adds *Accessories sold seperately.*) **App availability and experience varies by device and market. Office 365 subscription required for some features. ‡Limited to select premium phones at launch. Feature and app availability and experience may vary by market and device. Windows Hello required specialized hardware, including fingerprint reader, illuminated IR sensor or other biometric sensors.

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OPTIMIZE GAMING GRAPHICS

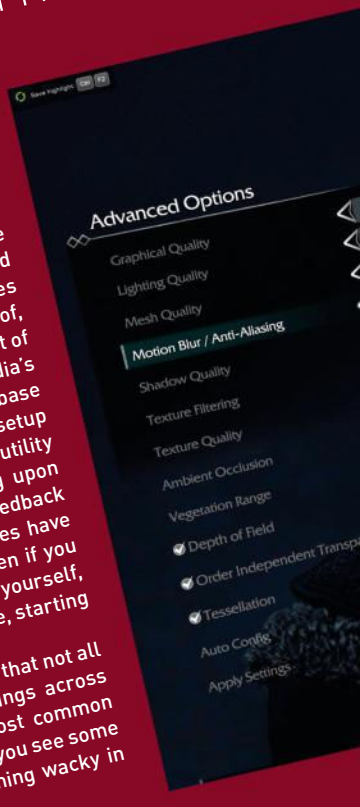
You want beautiful graphics and smooth frame rates? Immerse yourself in the wonders of your games' graphics settings and tweak them hard.

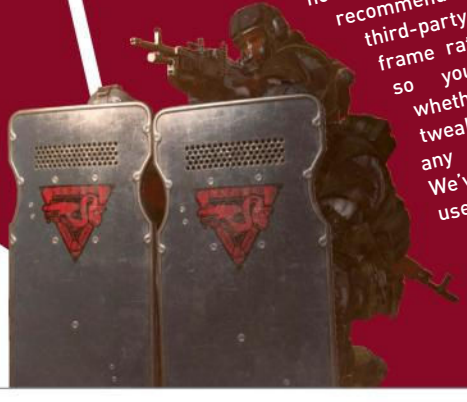
We all want the best. Of both worlds, if possible. For games, we want eye-searingly beautiful graphics, and we want them at silky-smooth frame rates. If you're lucky enough to have the very best and latest hardware, you should be able to play the latest and greatest games at the highest settings available. For the vast majority, though, some tinkering is needed to hit those smooth frame rates, and that's where this handy guide comes in. Over the next few pages, we'll pull apart all of the settings you're likely see in games, and tell you which ones are going to have the biggest impact on your frame rate counter.

Speaking of which, while it's good to go with your gut feeling about how smooth a game is, we recommend grabbing a third-party tool to show frame rates in game, so you can see whether your tweaking has had any real effect. We've traditionally used FRAPS for this, but have recently switched over to MSI Afterburner (http://gaming.msi.com/features/afterburner). You don't need an MSI card to use it, and it's free to download, so win-win all around, really.

While we're on the subject of software, one option worth pursuing is using Nvidia's and AMD's own tools to try to optimize your games for you. While these are by no means foolproof, they can do a good job of taking the pain out of the process—particularly on laptops. Nvidia's GeForce Experience relies on a huge database of settings and configurations to get the setup right, while AMD's Gaming Evolved utility provides a similar function by calling upon the gaming community to provide feedback on settings (which is why some games have no suggestions for optimization). Even if you intend to tweak your game settings yourself, these often make for a good, if crude, starting point for your experiments.

One last point: It's worth noting that not all settings are called the same things across all games. We've picked the most common names, but don't be surprised if you see some of these settings called something wacky in game. Right, on to the tweaking.





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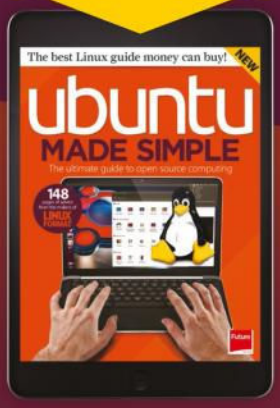

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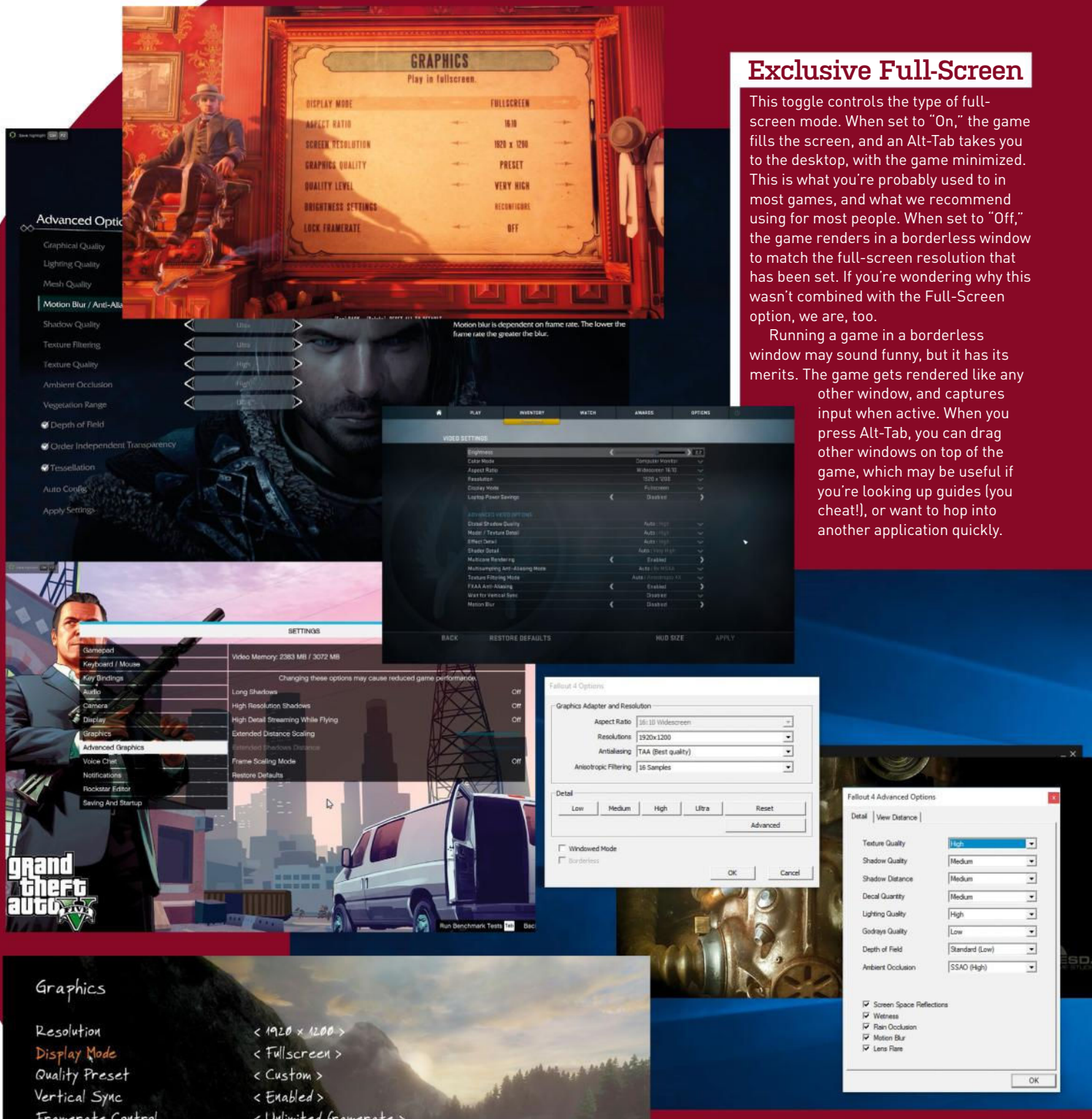


Exclusive Full-Screen

This toggle controls the type of full-screen mode. When set to "On," the game fills the screen, and an Alt-Tab takes you to the desktop, with the game minimized. This is what you're probably used to in most games, and what we recommend using for most people. When set to "Off," the game renders in a borderless window to match the full-screen resolution that has been set. If you're wondering why this wasn't combined with the Full-Screen option, we are, too.

Running a game in a borderless window may sound funny, but it has its merits. The game gets rendered like any other window, and captures input when active. When you press Alt-Tab, you can drag other windows on top of the game, which may be useful if you're looking up guides (you cheat!), or want to hop into another application quickly.

Full-Screen

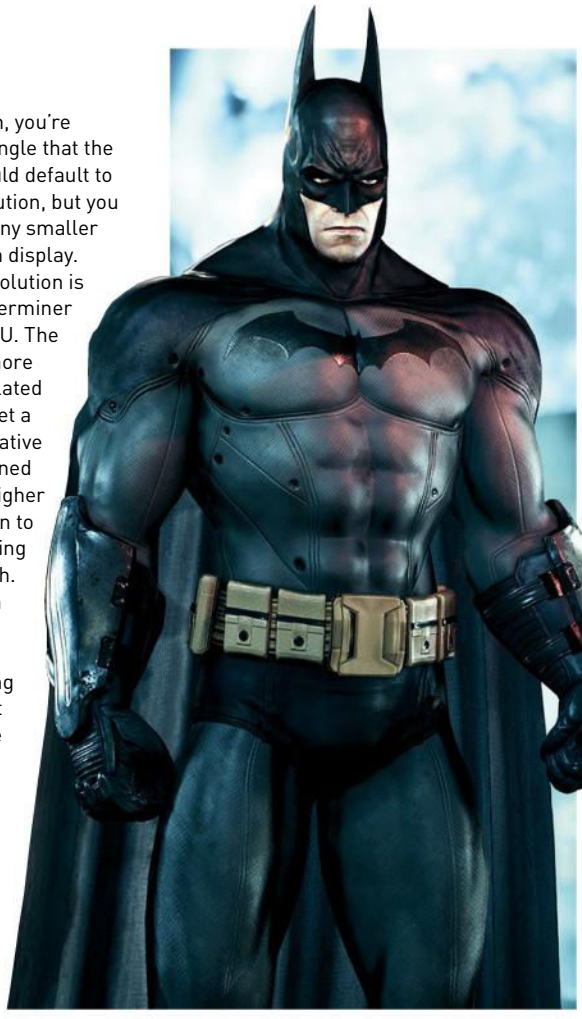
Most games enable you to determine whether the game will be played full-screen ("On") or in a window ("Off"). Generally, you'll want to play in Full-Screen mode, although those with multiple screen setups may have more fun with Window mode and some cunning window placement.

Resolution

When you set the resolution, you're setting the size of the rectangle that the game will render. This should default to your monitor's native resolution, but you can generally change it to any smaller resolution your monitor can display.

Changing the screen resolution is often the single biggest determiner of performance for your GPU. The larger the resolution, the more pixels that have to be calculated and rendered. If you can't get a decent frame rate at your native resolution with settings turned down, you can often get a higher frame rate by stepping down to a lower resolution and turning the other settings up a notch.

Running a game (or even Windows) at anything other than your screen's default resolution isn't ideal. Scaling to different resolutions isn't easy, and you'll see strange artifacts unless the render resolution is an obvious reduction of the native resolution. For example, running a 4K display at 1920x1080 is fine, as that doubles the size of the pixels. Running a 1080p panel at 1,024, however, will produce odd images.



Refresh Rate

The refresh rate should match one of the refresh rates available to your monitor. This allows VSync to work correctly. If you're not planning on using VSync (though you should probably be using VSync) you can sort of ignore this setting, but you should still set it to your highest possible refresh rate. (Hint: 24Hz without VSync results in even more tearing. Fun!)

VSync

Vertical-sync, or VSync, is a frame rate cap that the game or video driver places on the GPU. At first, VSync may sound counter-intuitive: Why the hell would you ever want to limit the output of your video card? Well, there are two big reasons.

First, VSync helps to synchronize the frame rate output with the refresh rate of your monitor. Without VSync, you can get what's called tearing, a nasty, glitchy-looking effect. In short, the screen output can contain portions of multiple frames, and when a lot of things change between frames, you get a horizontal split that's very visible. VSync causes frame buffer updates to only occur when the screen output isn't updating, eliminating tearing.

VSync can also improve stability and reduce heat. Without a frame rate cap to meet, your system happily churns out as many frames as it can. This requires the full effort of the GPU and CPU, meaning more heat and potentially a shorter product lifespan. Using VSync helps keep heat and GPU use under control. It can also smooth out gameplay, as a steady 60fps or even 30fps can often feel better than jumps from 60 to 200fps, and back.

The problem with VSync is that if your system is running just below your monitor's refresh rate—say, at 55fps on a 60Hz display—the next frame update always arrives after the screen update. On a 60Hz display, you end up running at a steady 30fps instead of 55fps, which some find too slow. If you're in an area that fluctuates between 55 and 65fps, it's potentially even worse, as you experience a stuttering effect, where a few frames update at 60fps, then you get some at 30fps, then back to 60.... But tearing isn't any better, which is why it's best to leave VSync on (unless you're benchmarking).

There is now technology to take care of the VSync problem. AMD's FreeSync and Nvidia's G-Sync allow your GPU and display to synchronize updates within a supported refresh range. So if your GPU runs at 50fps, your display refreshes at 50Hz. It can really improve the gaming experience, particularly if you're falling shy of the "magical" 60fps mark. The only problem is cost—FreeSync and G-Sync displays cost more than regular ones.

Tesselation

Tesselation is a fancy word that describes the subdivision of polygons into smaller polygons. Wait—what?

Three-dimensional objects in games are first rendered by drawing polygons, which are then covered with a texture. The fewer the polygons in an object, the more blocky it looks (think of a cube). The more polygons (or sides) you add to the object, the more round or defined its characteristics can be (think of going from a dodecahedron to a sphere). Tesselation is basically a way to use texture to take a flat object and add depth, by creating a bunch of additional polygons. It looks great, but it takes a bunch of computing power to do it. In graphics engines, tesselation is usually only done fairly close to the player (or "camera"), because there's no need to display details the player won't notice.

Antialiasing

Antialiasing is one of those settings that has a drastic effect on the appearance of a game. To put it simply, antialiasing is a type of edge blurring that attempts to make the transition between two adjacent, contrasting colors easier. This helps eliminate aliased edges, or "jaggies." If you've ever used Photoshop to zoom in on an image, and noticed how an outline or edge looks jagged, antialiasing is the equivalent of using the blur tool to make those edges a little softer.

After the screen resolution, antialiasing is frequently the next most "expensive" option to use. On top of that, the higher the resolution, the more expensive antialiasing becomes. However, there's a limit to its usefulness: Antialiasing is typically used to compensate for low pixel density screens. With a high enough pixel density, the effects of antialiasing become harder to notice. If you use a moderately sized 4K monitor (as opposed to a 40-inch monster), the physical pixels are smaller. That increased definition and accuracy often lets you do away with antialiasing, which results in some pretty big compute savings for the GPU. This doesn't work as well at 1440p or 1080p, so if you're gaming at those resolutions, it's a very good idea to turn on antialiasing.

There are several antialiasing modes available these days, and despite what we just said, the impact on frame rates ranges from mild to severe. Not all modes are available in all games, but here are the major ones:

FXAA (*Fast approXimate AntiAliasing*) will usually work just fine in most cases, and it's a type of post-processing—a smart blur filter applied to the final rendered output before it gets sent to the screen. It's very fast on modern GPUs, and is practically free to enable, though it doesn't always eliminate all jaggies.

SMAA (*Subpixel Morphological AntiAliasing*) is another post-processing filter, but it's supposed to look better than FXAA, with a similar performance hit. In testing, we've found SMAA tends to run slightly slower than FXAA.

SSAA (*Super-Sample AntiAliasing*) is one of the best-looking forms of antialiasing, but it's also by far the most demanding. It effectively renders the game at a higher resolution (2x or 4x your selected resolution), then samples that down to your native resolution. Unless you have an extremely beefy setup, you're likely to want to avoid SSAA and invest the computing power elsewhere.

TAA (*Temporal AntiAliasing*), as the name suggests, is concerned with dealing with aliasing that appears due to objects moving in a scene. It essentially renders more frames than are displayed, smoothing the movement of objects that are moving significantly faster than the camera's effective frame rate. This AA mode can be found in Bethesda's *Fallout 4* and *Skyrim*.

Anisotropic Filter

Anisotropic filtering helps to make sure textures don't look weird when viewed on surfaces that are closer to parallel with the user's gaze than perpendicular. The higher the setting, the better textures look when not viewed straight-on. It also blends the transition between mipmaps (different texture resolutions are used based on how far a texture is from the user; there's no need to use a 2K texture on an object that's so far away that it only fills a few hundred pixels).

While it used to be quite expensive, modern GPUs are adept at anisotropic filtering, though dropping it down to 2x may give you a couple of extra fps. We don't recommend dropping it down to trilinear, as anisotropic looks far better.

Depth of Field

If you've never taken a photography course, the idea of depth of field may be a little foreign to you. Don't worry—it's an easy enough idea to wrap your head around.

Depth of field has to do with the focal plane of a lens. A lens can only focus to a given distance. Depth of field determines how far away objects can be from that plane while staying in focus. A large depth of field means almost everything is in focus (like a landscape photo), while a narrow depth of field makes everything in front of or beyond the plane look blurry (think of a close-up of a flower).

This setting determines how much processing is allocated to creating a depth-of-field lens effect. For some, it may not matter, because the effect is often subtle. However, the setting does add a little polish to the way the game feels, so we recommend leaving this set to "On," unless you're really pressed for frames—and even then, the difference in performance is generally not very big.

Ambient Occlusion

If the objects in a game were like the contours of an object in a sketch, ambient occlusion is like the shading an artist would use to bring out the details. Ambient occlusion helps accentuate the contours of just about every object in the game, to create a better sense of depth. We highly recommend leaving this switched on. The game just doesn't look as impressive without it. If you've got a dozen extra frames to spend on quality, switching this setting to HBAO+ (Horizon Based Ambient Occlusion) yields even better results. This setting is computationally expensive, though, so we recommend leaving it switched off, unless you've got some serious graphics muscle to help kick it up a notch.

Texture Quality

The texture quality sets the size of the texture files that your game uses to skin the game models. Simply put, the higher the setting, the larger the resolution of the texture files, and the more graphics memory you need to hold those textures. There's a lot of processing that goes on with textures as well, so a higher setting also taxes the GPU more.

This is a setting that's often worth experimenting with if you're not getting smooth performance, as slightly lower than maximum settings still tend to look good. Conversely, if you're running a high-resolution display, you'll find yourself wanting the highest-resolution textures—even searching out third-party mods, if necessary.

Mesh Quality

Mesh quality affects how models look. The higher the mesh quality, the more details (and polygons) models have. The things you'll likely notice most are the tesselations and draw distance. We like to keep this setting cranked up to "High" or" Ultra."

Motion Blur

Motion blur helps give the illusion of speed by blurring objects to reflect motion. We like to keep it enabled, but if you're really trying to eke out a few extra frames, it's one more effect that's more like icing on the cake.

Level of Detail

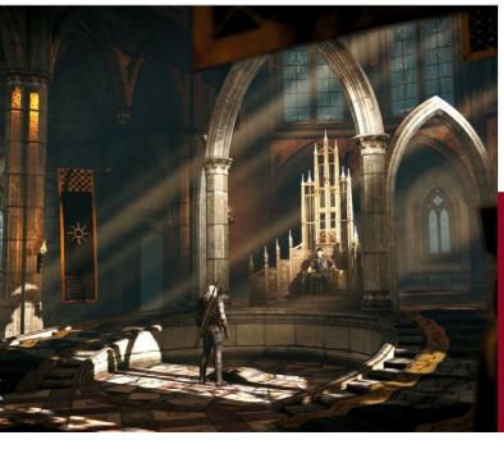
This sounds like a very vague setting, but it's actually an important one. It controls the number, draw distance, and quality of object meshes in the game. Higher settings require more processing power and memory, while lower settings can create good savings in terms of compute power.

Shadow Quality

This setting controls how sharp shadows appear in game. The lower the setting, the more "jaggies" you see in shadow effects. We don't recommend turning it to "Off," as it often ruins the atmosphere of the game. The difference in performance is generally not very big.

Field of View

The field of view affects, well, the field of view of the screen. If present in the interface (and not hidden away in an INI file somewhere), this option tends to range from 40 up to 109 degrees, and in most games defaults to 55. Unless you're using an ultrawide monitor, we generally recommend leaving this alone. However, some players prefer wider fields of view, enabling them to see more of the battlefield. Using a wider field of view does make the player models for the hands and weapons appear skinnier, though.



Bloom

Bloom enables the bloom effect when moving from dark to light areas, like that painful contrast between sitting in a dark room and walking out into a bright, sunny day that makes you wonder if you're part vampire. You can take it or leave it, but it won't destroy your frame rate to leave it on.

Lens Flare

This option should be pretty obvious. If you're reminded of Michael Bay every time you see a lens flare, feel free to turn this one off. If you like your lenses to refract light when pointed directly at a light source, though, you should leave it turned on. It's not terribly expensive in most scenes.

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Before and after: Driving sim and real-world at the same location on the same track.

Racing

Can a real-world car lover truly enjoy driving sims? *Jeremy Laird* is about to find out...

PC games let you do awesome stuff. You know, stuff like riding a dragon, building a city, commanding a Roman legion, wailing on a zombie with a big stick, or braining an innocent bystander for the dumb thrill of it. In other words, stuff that's either very hard or actually impossible to achieve in real life. Well, that and stuff that's thoroughly inadvisable, such as braining people. But driving cars? You can drive cars in real life.

Personally, I drive a lot of cars in real life, thanks to being a car hack, as well as a technology journalist. So here's the thing: I've loved PC games for as long as I can remember. I've loved driving cars for as long as I can remember. But driving games? Not so

reality

much. Since I learned to drive, my default position on driving games has been the assumption that driving even the most mundane shopping car in real life is more engaging than getting behind the wheel of a virtual supercar car. Or racing car. Or whatever.

But maybe I've got it wrong. Maybe the latest driving sims, complete with hyper-accurate physics, and force-feedback peripherals, not to mention the latest display technology, add up to something a real-world car lover can dig after all.

To find out, we're going to need to do this right. That means the right hardware and the right games. Jabbing away at the keyboard while sitting at a desk isn't going to fly. I'll need some kind of uber display, a full-on driving seat, a wheel, a pedal box—the whole nine yards. Then there's the software side of the equation. Will chasing realism be the key to enjoyment? Or is that always going to be a doomed mission, and keeping it arcadey, simple, and fun is the way to go? Either way, the learning curve is going to be steep; mistakes will be made.

Overall, then, this promises to be quite a ride, a dive into the unknown but shot through with familiarity. There's a fair bit of baggage, bias, and baked-in preconceptions to drag around the track, too. Can a real-world car lover, even one who is a big fan of PC gaming, really love driving sims? Let's find out.

Doing this in your own car is crazy fun. Can a driving sim really compete?

First, a confession. Depending on how you look at all this, you could argue that I'm a poor candidate for this gaming experiment. The problem is that I'm particular—and I mean really particular—about cars.

I prefer them analog and involving. The latest sports cars with paddle-shift gearboxes, driving modes, turbo engines, driver aids, and power-assisted everything leave me cold. Give me a manual gearbox, minimal computer intervention, and a zingy naturally aspirated engine, please.

In that context, the odds of me gagging on an entirely synthesized driving sim seem pretty solid. But the genie is out of the bottle. I'm never going to forget my experiences in real cars, and that's also what makes this experiment intriguing. I'm not an expert in driving sims. But I've got a little form in both PC games generally and driving. So, can I really come round to the delights of driving sims?

The theory of games and why we play them enters the equation, too. Isn't gaming about escapism, doing things you can't normally do in real life, like the aforementioned dragon-riding?

Of course, I can't race in the Indy 500 in real life. But I can drive a real car on a real track. If I really wanted to, I could get up very early tomorrow morning, jump in my car, and make it in time for a few evening laps at the infamous Nürburgring in Germany. While it wouldn't be cheap, it wouldn't completely bankrupt me. So the baggage I bring to all this is that I struggle to compute the appeal of a virtual Indy car compared with any kind of real-world driving. But hold that thought—we'll be coming to the question of cost momentarily.

PROJECTOR PROJECT

The first hurdle to leap is the hardware setup. Having just completed a new projector-powered gaming dungeon in my basement, the display tech takes the form of a gaming-centric short-throw projector, courtesy of the Optoma GT1080, a 1080p DLP model. Now, you might think a projector would be one of the more expensive parts of this project. At $699, the Optoma ain't cheap, but nor is it the four-figure bank account buster you might fear.

Admittedly, there are compromises at this price. The GT1080 has low-spec optics that make achieving a perfect setup in terms of image size, geometry, and focus tricky. It doesn't even have zoom adjustment; you physically move the projector to change the size of the image. But its short-throw characteristics mean it can be situated in front of the rest of the rig, and still fill my nine-foot screen.

As for the gaming PC, the beauty of this kind of setup, and using a 1080p projector, is that the demands on your system are pretty low. Driving games aren't hugely demanding, and driving a mere 1920x1080 pixel grid is peanuts compared to a high-spec PC monitor weighing in at 2560x1440 pixels, or more. So my spare rig, running an elderly AMD Radeon HD 6970 and a two-year-old quad-core Intel Core i7, is plenty.

From here, it gets trickier. One of the big surprises for me has been the cost of driving peripherals. One of the main reasons to play a driving sim rather than really drive is cost. Driving any kind of car is expensive. Racing is one of the best ways ever conceived to make a small fortune, but the problem is that you

VIRTUALLY PERFECT

Are VR and driving sims a marriage made in gaming heaven?

There's a lot of debate over how suitable the new VR headset duo is for various types of gaming. But most agree the big problem involves moving around in the virtual game world. It's a major problem to simulate walking around a game world, even with a big space. You soon run into the limitations of the real world.

But driving games don't have that problem. You sit in the seat and that's it, just like the real world. Bodily, there's no need for you to move another inch. Perfect. What's more, a VR headset helps a lot with one of the trickiest bits in adjusting to a driving sim: depth perception and judging distances. Combined with minimal physical feedback, it can make things such as picking braking and turn-in points, along with generally positioning the car on the track, much harder in a sim than real driving.

If there is a problem with using a VR headset, it's not specific to driving games. It's that screen-door effect, due to the limited resolution that impacts all gaming. It's a problem that will almost definitely be solved with higher-resolution iterations of the HTC Vive and Oculus Rift in future. For now, it's something you just have to adjust to. Of course, it's also worth remembering that VR headsets are very demanding when it comes to rendering power. You're pumping more pixels at a higher frame rate than when using a 1080p projector at 60Hz refresh, that's for sure.

A VR headset is probably the best overall display solution for fully immersing you in the driving sim experience. But we found that a short-throw projector was a remarkably effective second-choice setup. The caveat to that is that you'll have to put a little work into getting the field-of-view settings right to give you the most realistic view out of the car. Switching off the rendered steering wheel, and sticking with simply the view through the windscreen, makes sense, too.

Start your engines: The gaming dungeon is ready for action.

On board and kind of up to speed.

must start out with a very large fortune. Racing cars will wipe you out financially.

DRIVING PRICES UP

Now, I'm not saying that driving sims are on anything like that level. But it was still a double-take moment when I saw the price of the Thrustmaster TX wheel and pedal box combo. $468 for some gaming peripherals? And we're not even talking about high-end enthusiast equipment.

The final major piece of the puzzle was a driving seat. For that I turned to one of the bigger boys in this part of the market: Playseat. The Playseat Evolution Alcantara model pictured here rocks in at $369, and there are other, similar models available for around the same price. Admittedly, it has a few limitations, as you can read about on page 33, but it was still the one item that was a little more affordable than I was expecting, especially given how important it is to achieving an authentic feel.

With the projector aligned, the seat assembled, and the Thrustmaster bits installed, I was good to go. The only question was what to play? The options were realism with a high-end sim on the one hand, or simple thrills with something arcadey on the other. My hunch was that a full-on sim was more my thing. I also had an inkling that trying to get as close as I could to my own real-world experience would be an interesting way to get things rolling.

For better or worse, the game I chose was *Asseto Corsa.* Apart from reading good things about *Asseto Corsa's* driving dynamics, it offered a couple of crucial features. First, I could start on a track I've driven in the real world, namely the one-time Formula 1 race track that is Brands Hatch, just outside London in the UK. It also included several cars I've actually driven, including a second-generation supercharged Lotus Elise.

So this is how it all began. First, some tweakage in *Asseto Corsa's* settings. I didn't want to make things too easy; I wanted the full deep-end experience from the get-go. So, I turned off the stability and traction control systems. The result was shocking. On my very first lap out of the pits, braking

BUILD YOUR OWN DRIVING SIM

It's expensive, but worth it

So, you're interested in rigging up a driving sim. What are the bare minimum ingredients, and what's recommended for the best experience?

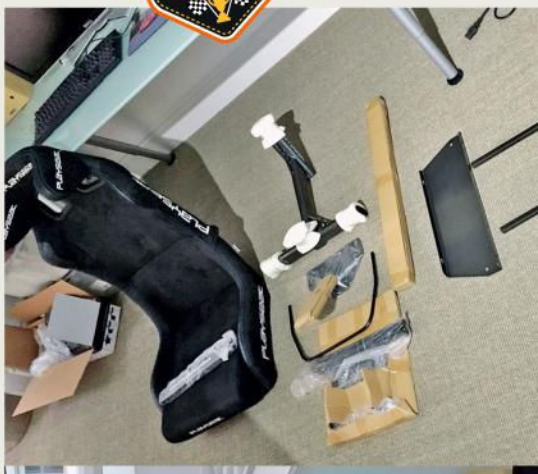
Perhaps contrary to what you might assume if you have no previous experience of driving sims, peripherals—rather than display technology—are the most critical components. We would recommend a proper seatpod, along with both a decent force-feedback wheel and a pedal box.

As we found, those items can quickly add up to serious money, especially if you want a pedal box with decent feel, thanks to load cell technology. You could easily spend $1,000 for your seat, wheel, and pedals. Scary.

We've touched on the VR display option on page 30, but if you're going with a more conventional screen, size is more important than resolution for driving sims. 1080p on a big display is plenty, which means a cheap HDTV can work well. Multiple monitors for an expanded field of view can be great, too, but obviously come with cost implications. The projector option we went for worked surprisingly well, but it can be tricky to set up, and it's less flexible. Even really bright projectors really only look good in low ambient light conditions.

As for your actual PC, if you're going down the 1080p display route, via some kind of flat panel or a projector, you won't need all that much graphics firepower. A mid-range GPU and CPU combo should be plenty. Go for a multi-monitor or VR solution, though, and you're going to need high-end graphics. But, then, your budget is probably going to be that much bigger, anyway.

Overall, getting into driving sims and achieving a decent experience isn't going to be cheap. There's no avoiding that. But if you already have a large display of some kind, you can get most of the fun for under $1,000.



There's a little DIY involved in the assembly, but the result looks seriously slick.

into what's known as the "Graham Hill" corner on the Brands Hatch Indy circuit, it felt like my guts were trying to exit my body through my feet. Genuinely, it was intense.

Very likely, it was the combination of the huge screen filling my field of view, the Playseat delivering a familiar seating position, the steering wheel tugging at my hands, and the noise filling the gaming dungeon. Whatever, my brain was fooled into thinking there was some real driving going on, so when I was braking into that downhill corner, it was confused, and began to generate some intense and completely phantom physical sensations. It was as though I had a hydraulic rig operating in my mind. Truly, it was weird.

The intensity calmed pretty quickly over the opening laps, which I might add were messy as hell. From there, I could begin to get to grips with the whole experience of driving sims, the things that were familiar, and the things that were completely alien.

One of the aspects that works best is the steering feel. The *Asseto Corsa* team has done a very nice job with that, and the Thrustmaster wheel really delivers, too. Overall, I was very impressed with how the essential character of the Lotus Elise's rack has been captured. It's not a perfect or complete rendering, but it's on a completely different level from what I was expecting, and it's surely a big part of what made for that intoxicating initial experience.

FOOT NOTES

At the other end of the scale is the pedal feel. Put simply, it's crappy. Nobody who has even the most cursory understanding of cars or driving signed those Thrustmaster pedals off. The biggest issue is the brake pedal, which is far too long in travel, and too soft and springy in action. It's horrible.

At this stage, a little research taught me that what I need is a pedal box with load cells, which allow brake modulation based on pedal pressure, rather than pedal movement. That can be achieved with certain pedal boxes via aftermarket modifications, though I can't comment on how easy or effective that is. Or you can snag a pedal box that comes complete with load cells from an outfit such as Fanatec, though that will add around $400 to your driving sim bill of materials.

Once I began to get to grips with the basics and the weirdness, what was really fascinating was that I found myself in much the same rhythm that I do during a track day in real life. Working on lines and braking points, feeling frustrated with my lack of talent, but pounding round and occasionally being rewarded by momentary exhilaration when I nailed a corner just right, or finally

If you can drive the Nürburgring in real life, does that make racing sims seem silly?

An unpromising jumble that quickly turned into a serious seating solution.

PRIMING THE PLAYSEAT

A good-quality seat is crucial

Doing driving sims right means acquiring a whole hill of new hardware. One of the most critical items is a driving seat. We can't overstate how important being in the right seating position is for mimicking that authentic behind-the-wheel feel. Bolting a wheel to your desk and plopping yourself into an office chair just ain't the same.

Enter the Playseat Evolution Alcantara. It's one of the more affordable seatpods in Playseat's range, at $369, but it's a full-feature job, with an adjustable bucket seat, and mounting plates for a wheel, pedal box, and gearshift. There are other similar models available for around the same price, or more.

Initial deboxing impressions involve an unpromising and slightly intimidating jumble of parts. But the instructions are clear, and assembly is much simpler than anticipated. Twenty minutes later, and you'll have a rather sexy looking seatpod.

Overall, there's plenty to like. The bucket seat is probably a little broad for my skinny frame, but the result is still the right kind of seating position to put you in the mood for driving. If there is a problem, it concerns the lower forward part of the steering wheel support. It clashes, ergonomically, with the pedal box platform, making it tricky to get both the pedal box and the wheel in ideal locations.

The oversized proportions of the Thrustmaster pedal box we've paired with the Playseat make matters worse. But the design of the wheel stand makes it likely you're going to run into at least some problems getting an ideal pedal position.

For that reason, our recommendation from the Playseat range would be one of the Revolution models. The Revolution has a tweaked steering wheel mount that solves ergonomic conflict with the pedal mount. It's otherwise very similar to the Evolution seatpods, and roughly the same price. Thus, it's a bit of a no-brainer. Head to www.playseatstore.com to browse the full Playseat range.

understood where I was getting something wrong with my braking points or turn-in. It was a hell of a lot of fun.

But the really impressive bit, in terms of confirming how realistic the sim setup turned out to be, is that I was quickish in the same parts of the track, and was struggling to find the absolute best line in the same parts, as I am when driving the circuit in the real world. That, I think, is remarkable.

BRAKING POINT

On the other hand, there was plenty that was different about sim driving. Those pedals make judging braking points darn difficult. I found it a real challenge to judge entry speeds, too. But the biggest issue is the lack of feedback beyond the steering. Seat-of-the-pants feedback, what you might call your built-in G-sensor or butt dyno, is such a big part of driving a real car, and its absence in driving sims—at least, when you aren't running some kind of mega-money hydraulic rig—is the biggest limitation when it comes to realism. I often feel disconnected by modern cars in the real world, but that problem is far worse when it comes to driving sims.

I did also try the arcade-style option, courtesy of the *Forza Motorsport* demo for PC, but almost instantly I knew that style of gaming isn't for me. Realism to the max, please. Overall, the whole experience left me with mixed emotions. In many ways, driving sims are massively more realistic and engaging than I dreamt possible. But when the initial euphoria cooled, I realized that a long-term driving sim habit would be a serious commitment.

Firstly, I'm sure that online competition is what I'd need to fill that hole left vacant by the limited physical feedback. But I also know from my *Counter-Strike* days that being even half competitive online is a hefty commitment. You need to be at it all the time just to keep up.

Then there's the temptation to tumble down the rabbit hole of super sims. I haven't put enough hours in to really run into the limitations of the Thrustmaster wheel, but that would almost certainly happen in time. Then I could see myself going through multiple upgrade cycles with both the wheel and the pedals, and maybe even the seatpod, too. It would be all too easy to spend thousands of dollars chasing the perfect super sim setup. That's a little scary, and also makes me ponder the point of it all. For a few hundred bucks, driving sims are good, clean fun. But if I have to spend thousands to keep my interest levels up, that's a whole different ball game. The harsh truth is that I'd prefer to spend those dollars on real-world driving.

STANDING ROOM ONLY

Standing desks are heralded as the healthy future for PC use, but what's the reality? *Dan Griliopoulos* finds out

Let me start by nailing my allegiances to the flagpole. I use standing desks on a daily basis. My first standing desk was homemade. Five years ago, my doctor said that my long-term back problems were a result of the amount of time I spent sitting down, and I had to reduce it. I said I simply couldn't stop sitting down, because I'm a writer. He said that I had to stop, if I wanted my back to ever get better. So I rebuilt my cheap desk using spare planks and boxes, until I had something fairly stable that was standing-only. Two years later, I moved house and dismantled it.

Now, standing desks are a standard part of many offices. It's not unusual for larger offices to offer them as an option for people who have a medical reason for using them. Some companies are more enlightened and allow anyone to request them. A recent study of Swedish call center workers revealed that 90 percent have access to such desks.

With that popularity, a huge array of companies has sprung up to provide desks. Companies such as Ergotron, Varidesk, and more supply a range of standing, sit-stand, and modular desks that range from around $150 up to $1,000 or more. (Sit-stand desks are of variable height, enabling users to switch between sitting and standing while working with the minimum amount of interruption.)

Weirder desks are less commonplace but do exist. Treadmill desks, for instance, were a trope of near-future science fiction for years before they became a mass-produced consumer object. Augmented and virtual reality will take desk design into even stranger places, because they eliminate the need for physical ergonomic designs entirely, shifting the focus to appropriately designed flooring and software that can adjust to a user's physical needs on the fly.

So why get a standing desk? Are they actually that much better for you? And if so, to whom are they best suited? Who should avoid them? And where's the best place to get them?

VARIDESK.com
VARIDESK.com

Why did we start sitting down to work? It seems to have been a huge mistake—talk to any physiologist and they'll bemoan this alteration in the human condition. The human body is subject to enough frailties without a compression into an unusual posture, resting on the wrong parts of the physique. A thousand problems wait to bedevil us because our bodies aren't suited to this work situation.

The first problems, and the most noticeable, come from your joints, but there are many others. Betsey Banker, the wellness manager at standing desk manufacturer Ergotron, explained more to us. "A sit-stand routine breaks up sedentary time, which we know to be harmful, and can have a positive impact on mood states, productivity, stress, and body pain, regardless of current health status. People burn more calories when standing, have increased blood flow, and greater insulin effectiveness, so it can even help manage or reverse metabolic syndrome. The key is to have a balance of sitting and standing, staying in line with the ergonomics standard of neutral posture, motion, and rest."

Medical researchers have warned that sitting for long periods is associated with poor health. The longer you spend sitting, the larger your chance of getting a whole host of illnesses. You have twice the rate of type 2 diabetes and cardiovascular disease, and a substantially increased chance of cancer and death. It's worth noting that most of these studies have been associational—that is, they haven't proved causation—but the associations are pretty horrific.

However, two recent studies did prove some health benefits. First, a team at Uppsala University in Sweden showed that "not sitting" was actually better for you than exercise (in terms of DNA damage, anyway). Second, a team in Louisiana used a huge existing database of physical activity among Canadian adults to test the effects of standing. They found that the more you stand, the less likely you are to die.

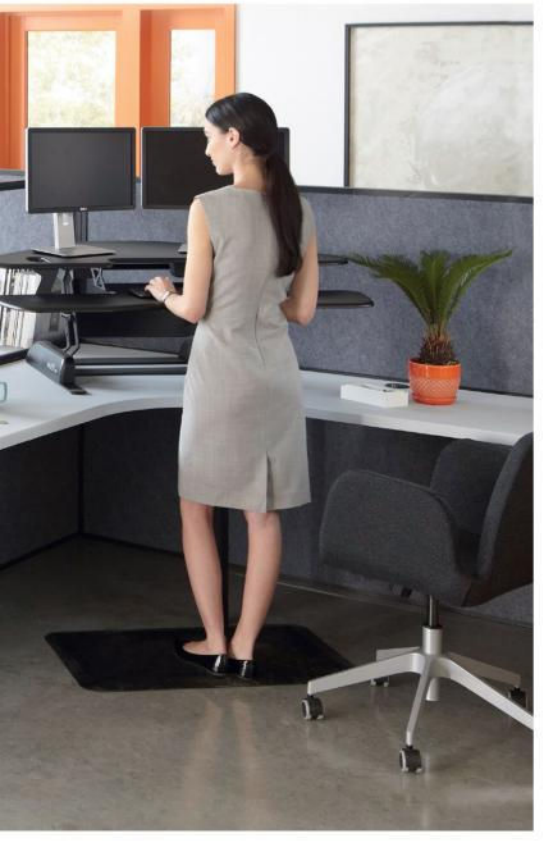
Brad Shipps, an expert at Varidesk, says, "A sit-stand desk is one of the best ways to combat what the Mayo Clinic, one of the leading medical research centers in the US, calls 'sitting disease.' There has been so much research on the dangers of 'sitting diseases' that last year the British government suggested that everyone stand at least two to four hours a day." He's right—an expert panel, convened in the UK by Public Health England, made recommendations about improving work health, which included simply standing, moving, and taking breaks for at least two hours out of a typical eight-hour day. That could be standing or walking meetings, pacing, taking calls standing, using the stairs, walking over to talk to colleagues rather than emailing, and actually taking your darn lunch break.

Above: **Specialized standing surfaces aren't necessary but are recommended.** ***Left:*** **A clamped sit-stand desk is hugely flexible.**

DON'T TAKE IT LYING DOWN

Of course, standing desks can help with a lot of this, as well. There are secondary advantages, too. "Using a sit-stand desk is also a means to increase daily low-level physical activity, which is important to our health," says Banker. "Low-level activities, also known as NEAT (non-exercise activity thermogenesis), can even have a greater impact on overall daily calorie expenditure than exercise."

On top of that, some studies have shown that productivity improves as much as 15 percent when people are standing. "A workstation that changes positions in 10 seconds or less allows the user to sit or stand as needed, without interfering with workflow," says Banker. "The ability to change positions easily, without interruption to thought processes, aids productivity in the workplace, and studies in education do



link greater user focus and engagement to the introduction of stand-biased desks.

"Some of this is anecdotal, but we do hear about people claiming they are sleeping better, feeling more energized throughout the day, and are even making better choices about other exercise they do during their day, or what food they eat. There is a tendency to be more prone to recognizing other sedentary parts of the day, and to start making changes to break that up, too, like TV-watching or computer time at home. Or when out and about, like standing at a tall table at the pub versus sitting on the stool."

Starting to use a sit-stand or standing desk can be a slow process. Listening to your body is key. It gives clues as to when it is getting tired in either seated or standing positions: muscles start to ache, fidgeting begins, distraction sets in, or comfort is elusive. These are all signs it might make sense to change positions. "Once someone is into a routine, they may discover that certain tasks relate to sitting versus standing," says Banker. "By understanding how your energy flags throughout the day, using the workstation to monitor energy is a good idea. For instance, after lunch, stand in the afternoon to fight off sleepiness. The same is true for meetings." Challenges with co-workers or software tools can help maintain motivation, as can remembering why you're standing more!

STANDS TO REASON

So which desk should you choose? There is a variety of desks you can buy. The simplest are cheap desktop units that sit on top of other desks. Ergotron, Startech, and Varidesk all supply such units. Whatever your physique, it's worth using a calculator to work out the dimensions of the desk you'll need. Ergotron has a simple interactive one at http://planner.ergotron.com.

If you're taller, your choices are more limited. You need a high-rising leg system on the desk that has minimal wobble at full extension. For example, Ergo Depot's Jarvis can accommodate people up to 6' 7"—half a foot higher than most desks can manage.

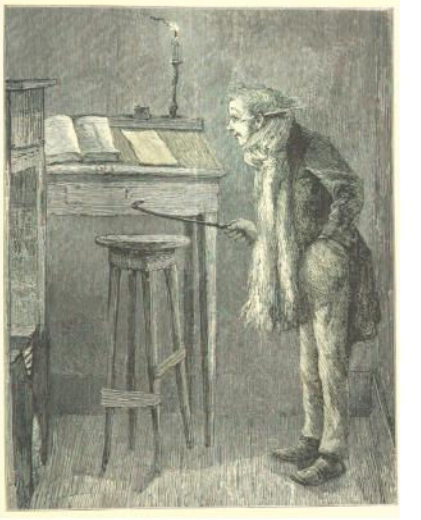
The Jarvis is also motorized, unlike many desks, which use counterbalances. Motorized desks are easy to use, but can be slow. The lighter Jarvis Bamboo, for example, takes 20 seconds to extend, rather than almost instantly with counterbalanced desks, as Shipps points out: "With a manual adjustment desk, there's nothing to program or plug in. But it still has to be easy to raise and lower. That's why we designed the Varidesk with a spring-loaded boost mechanism, so that even with a fully loaded desk, users of any height or fitness level can go up or down in just a few seconds."

"Certainly, mechanical desks also offer smooth up or down motion," agrees Banker. "But one has to accommodate the transition time interruption that you don't find in counterbalanced desks. Instant change from sitting to standing minimizes interruption." Motorized units also have preset heights they can extend to—not great if your comfort zone is between them.

That said, many counterbalanced desks need adjusting to reach the right tension. "Fully understanding the adjustability is a wise step," advises Banker. "Most products have tension to counterbalance the weight of the electronics and make lifting and lowering easy, so you'll want to tension your product until it goes up and down easily."

What's noticeable is that many standing desks have metallic or plastic finishes—

> "The longer you spend sitting, the larger the chance of getting a whole host of illnesses."



© Image courtesy of the British Library

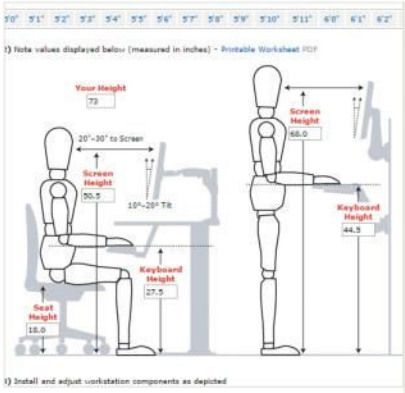
UPSTANDING HISTORY

Historically, it was normal for people to read standing up. If you look at old photos of 19th century offices, or engravings like the one above (from *A Christmas Carol*, depicting Bob Cratchett's workspace), you'll see that it was quite usual for workers to stand up to work—a sloping desk enabled them to bend over their work more easily. An 1858 self-help book pointed out that standing desks supported "nearly half" of all business writing.

Go further back, and it was still normal practice to read standing up. Look in an old chapel and you'll see the priest's lectern, a hangover from that era. Famous men of history—Dickens, Churchill, Jefferson, Rilke, and Da Vinci—also used standing desks for writing, proofing, reading, and designing. Indeed, draftsmen today often use desks that are very similar to those from that era.

So, why and when did we start sitting down? Looking at the frequency of the phrase in books (using Google's essential Ngram viewer tool), there's a pretty clear decline in the mentions of standing desks, from a large peak in the 1890s to the early 2000s, when there's a resurgence.

By the 1950s, when Hemingway was still using a home-made standing desk, it was seen as an anachronism—when the sports journalist George Plimpton visited him, he saw a "perfectly suitable desk in the other alcove" from Hemingway's typewriter, which was atop a bookcase. Perhaps it was the post-war era of mass production and molded furniture that finally killed them off—the larger, lower, office desk, with its easy chair, may have been a symbol of luxury, which mass-produced materials made affordable to the majority of people. Certainly, by the 1960s, they were long gone.



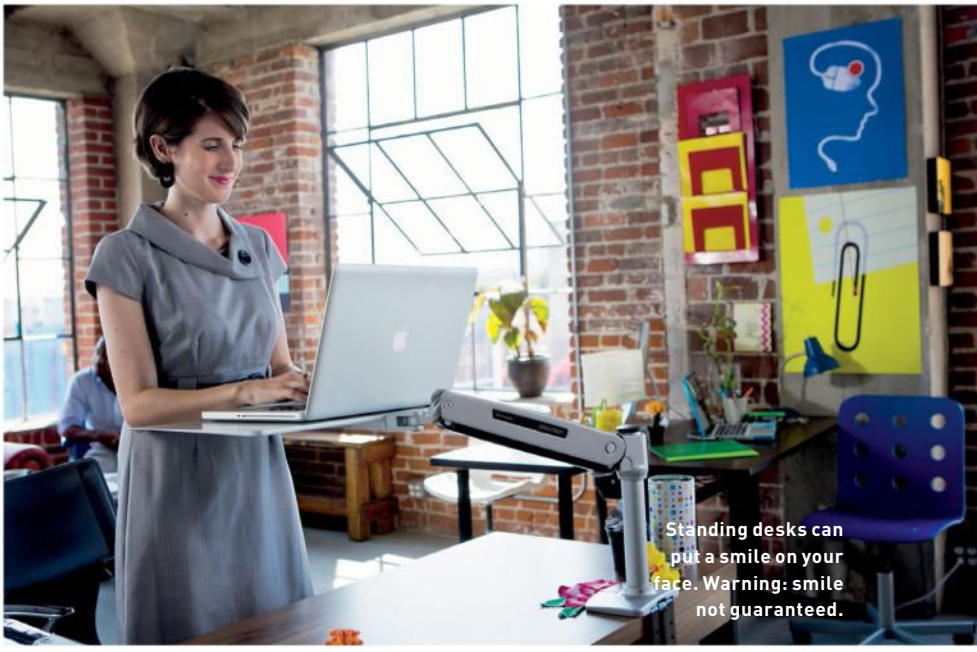
THE BODGE

Building your own standing desk is easy. We recommend starting with a basic, cheap desk—if it has a raised back, all the better to support the monitor. For example, the Ikea Fredde and Micke desks both have good shelved backs. Then it's a simple case of taking sturdy boxes, planks, or large books and fixing them down, so there's a platform for your keyboard to sit upon.

And do pay attention to our experts' advice. Varidesk's Shipp has no problem with home-made desks. "First, I've got to say that I'm impressed with some of the ingenuity and imagination I've seen in the DIY standing desks. But I'm not always sure how safe they are, and very few of them are adjustable. A Varidesk is adjustable, comes fully assembled, sits on top of almost any desk, and has our 30-day no-risk guarantee. Also, you aren't locked into just one position all day."

Banker agrees: "Home-made versions frequently lack even basic ergonomic features for wrists, shoulders, and neck—not surprising when many are made from empty boxes or crates. Ergotron, for example, designs products with user ergonomics in mind, taking into account keyboard and monitor positioning, and height-adjustability, to meet 95 percent of the users for an overall better working experience. When creating a hand-made option, using a simple calculator like Planner.ergotron.com helps work through important ergonomic considerations."

Two things are essential for the desk to be adjusted correctly. Firstly, the top of your monitor should sit roughly at eye level, so you're not craning your neck up at it or bending down. If this is incorrect, your posture suffers, and your back curves unnecessarily, at either your shoulders or lower spine. Secondly, your hands need to be resting flat on your keyboard, not stretched up or down. This prevents RSI. That means your keyboard should be at the same height as your hands, while your forearms should be parallel to the ground.



Standing desks can put a smile on your face. Warning: smile not guaranteed.

especially those intended for a mass-purchase office environment. Most don't match up to the beautiful designer or antique desks you can buy, often for less than the price of a sit-stand model.

That said, because they're not attractive, customizing them won't make them look worse. Adding extra monitor mounts or an adjustable keyboard tray are common options. And be aware that you'll probably need longer cables for all your gear.

What would Banker choose? Well, she has a message to send: A well-designed sit-stand desk is superior to any other type, especially a home-brew one. But she does make some good points: "The ergonomics and adjustability are clear differentiators between home-made solutions and pre-built. Often, people only have the means of building a fixed-height standing desk on their own, which sacrifices the ability to regularly switch positions, or may require a change to a tall stool or chair."

Indeed, in the case of my home-brew desk, I could only manage a couple of hours a day to start with. I bought an old bar stool to perch on when I got tired—if you want something similar, try searching for an artist's stool or drafting chair. This was an effective way to use my home-brew desk without working out a way to make it raise and lower—but I found myself sitting on it more than I was standing.

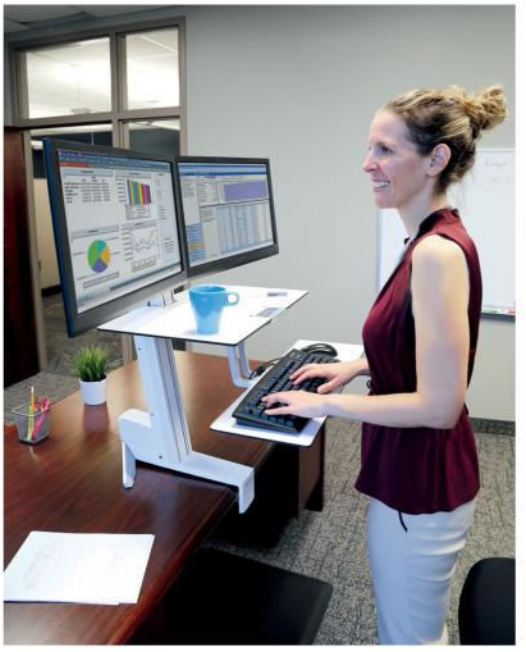
Not that fixed-height desks *per se* are problematic. "To a certain extent, if the fixed-height situation is customized to the individual user, and a tall stool or chair is deployed, this is a viable solution. Especially when starting out, going from 100 percent sitting to 100 percent standing is hard on the body," says Banker. "A common approach is to gradually introduce more standing into the day over time. For example, start with 10 minutes an hour during the first week. The gradual transition allows time for the body to adjust, as muscles are now being active that had previously been underused."

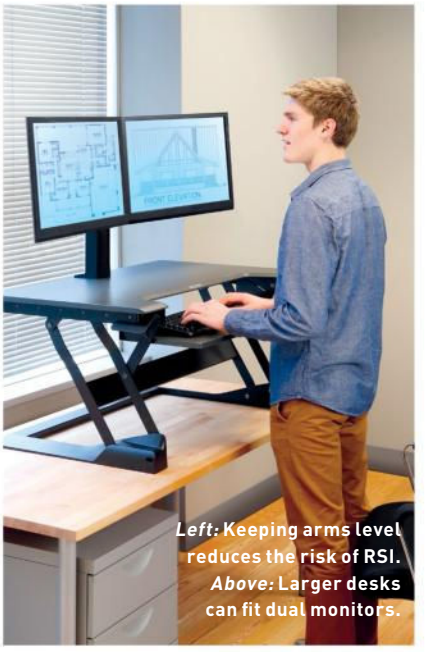
You should also consider the comfort of your feet, considering how much extra strain they'll be taking. Shipps recommends standing on a support mat: "Most people find that using a cushioned anti-fatigue mat is the way to go—especially on hard floors like tiles or concrete. They make a huge difference to improve the comfort for your feet, legs, and back." For new users, Banker recommends wearing comfortable shoes, and for women, shoes with low heels, so that no matter what floor surface, feet and leg stress will be minimized.

Are there groups that particularly benefit from standing desks? Well, I have sciatica—a form of severe back pain that's aggravated by sitting for extended periods. Sit-stand desks are great for me, providing I use them in accordance with the advice of a health-care practitioner.

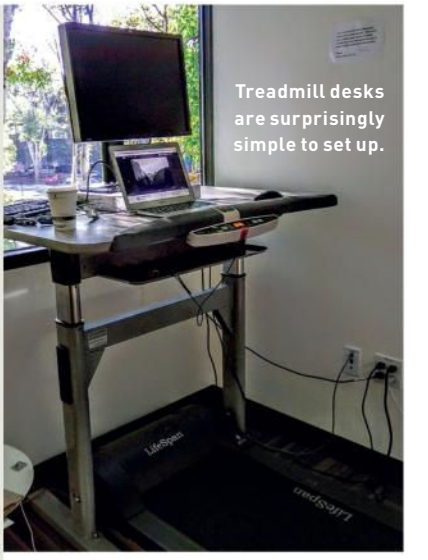
"Research indicates that sit-stand may reduce current back and neck pain, so it's likely that someone with back pain will actually find relief," says Banker "Stanford University just released a study that showed that access to sit-stand workstations began making a difference for workers after about 15 days.... Some businesses use sit-stand workstations as a prescriptive solution for employees experiencing significant pain, like lower back pain."

People with back problems do need to take particular care—motorized or well-





Left: **Keeping arms level reduces the risk of RSI.**
Above: **Larger desks can fit dual monitors.**



Treadmill desks are surprisingly simple to set up.

©Travis Wise

counterbalanced units are important. "Finding a solution that does not put additional force on the body is key," says Banker. "Look for units with easy height adjustability and proper ergonomics (being able to raise and lower the desk without having to reach far away from the body or use high levels of force). People may also want to consider using a foot stool to prop up one foot when standing, as it relieves pressure on the lower back."

Not that standing desks are solely for the infirm—as we said, they have health and productivity benefits for workers of all capabilities and ages. Indeed, Banker points out that many businesses with sedentary workers, such as call centers, consider adopting sit-stand desks across that entire division. "Office workers are a big market, but Ergotron is seeing students responding very favorably to adjustable desks as well. Kids as young as fourth grade understand and positively respond to their body's need to move more. We also see what some consider 'the worried wealthy,' who are looking for proactive means to manage their health, and like the added calorie burn and energy boost moving more at work affords."

That sounds dangerously like a fad—albeit one that's been going on for a few centuries, as Shipps points out: "Considering that Churchill, Hemingway, and Thomas Jefferson all used standing desks, that would be the oldest fad I've ever heard of! With all the research coming out about how dangerous it is to be sedentary, I can't imagine us going back to sitting at our desks all day. That would be like everyone starting to smoke cigarettes again."

This latest incarnation has only been around for five years, though, and may fade out again as people remember how lovely a nice sit-down is. But what's more likely is that it'll spread to more businesses and homes, as people understand how healthy it is. Banker calls it a "workplace revolution of sorts," as businesses take environments that promote the health and wellbeing of their workers more seriously: "Even global health organizations are weighing in on how to best help business break up sedentary time for workers, such as the World Health Organization, which identifies physical inactivity as the fourth leading risk factor for global mortality. We live in a technological age, where many jobs are computer based, so adding physical activity is imperative to our health and sustainability."

> "Going back to sitting at desks all day would be like everyone starting to smoke again."

Despite all the benefits of standing desks, Ergotron's JustStand Index shows that only seven percent of the US public are aware of the problems associated with sitting. Raising that number and returning the population to the health benefits that our grandparents enjoyed is a simple step. We just need to take a stand.

BEYOND STANDING

Treadmill desks are the logical extension of the standing desk concept. If standing is so good for you because it enables you to move around, goes the thought, then running must be super-healthy. And, although a lifelong user of standing desks—such as Donald Rumsfeld, say—no longer feels tired after 10 hours of standing, for most people, just standing for an hour can be exhausting.

However, there are problems. Walking while typing is a difficult skill to learn at first. Meanwhile, many treadmill desks don't even come with a treadmill—and some specialized treadmills are sold without a desk! On top of that, most of them are pretty ugly or badly designed. This is probably because the industry is still at an early stage, and most desks are just generic, mass-produced ones.

We can recommend TrekDesk's desktops, though. Although they're not comely and come without a treadmill, they're very cheap—around $400—and you can pick up a small treadmill for another $200–$300. At the other end of the market, LifeSpan's integrated treadmill desks are robust, attractive to look at, and full of useful features, such as integrated Bluetooth, which can report your exercise to health apps—but they are rather expensive, ranging from $800 to $3,000.

If you're thinking of buying a treadmill desk, test it out first. Ensure that the treadmill has a good top speed, is wide enough for wandering feet, and the motor isn't too noisy. Check that the desk is robust, with easy-to-access handholds to support you when you need to take a break. If you're willing to pay a little more, invest in a treadmill that doesn't need lubricating every few months.

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HARDLINE LIQUID COOLING

The pinnacle of water-cooling beauty: the hard-piped build

There's something indescribably beautiful about a hard-piped, liquid-cooled build. Those smooth elegant lines, subtle curves, and piercing sharp reflections dancing around the interior of your chassis, as the coolant flows through it, glorify any rig; taking it from the bland basic hardware it once was, and transforming it into something magical, something exceptional.

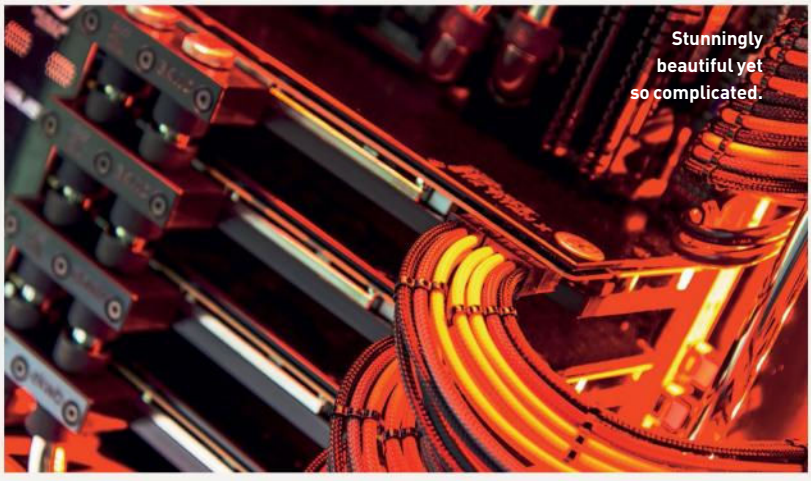
Is it easy? Well, it's a lot easier now than it ever has been. But it still takes time, patience, and—most importantly—a sizeable chunk out of your wallet. It's easy as pie to set up your own soft tubing custom loop nowadays, but if you're thinking about taking it one step further, and opting for the hard-piped variant, you're more than likely going to be forking out a hell of a lot more money and time. Why? Well, it's purely down to effort, and what effect that has on how you plan your build. To be blunt, bending tubing, although fairly easy once you've got the hang of it, takes practice, and often a considerable amount of time. It can be exceptionally frustrating. On top of that, hard piping adds nothing more to your build than aesthetic beauty; you gain nothing from using hard tubing over soft tubing, or vice versa. That being the case, cooling just your CPU, although entirely possible, tends to come across as a waste of time. You'll want to throw a GPU in that loop as well.

When it's finished, that's when the magic happens. That's when you can sit back, admire the angled fittings, listen to the low hum as your fans spin at sub-1,000rpm, stare at HWMonitor as it registers your CPU clocking in at a comfortable 45 degrees under load, and just thoroughly enjoy it. Liquid cooling, particularly hard piping, is for the artists, for those looking to get the most out of the hardware, for the overclockers, for those who enjoy building something unique, and it's well worth your time to put together.

by Zak Storey

NZXT.
DDC X-Res 150

WHY WATER COOL?



Stunningly beautiful yet so complicated.

WHAT'S THE POINT of water cooling? We hear that a lot. After all, for most people, who don't have pre-binned hardware or vast quad-SLI/CrossFire rigs, you're simply not going to gain much from it, right? Why not just get an AIO cooler and a set of super-silent Noctua or Noiseblocker fans instead?

Multiple reasons. Firstly, your loop will be bespoke. Every water-cooled rig is unique. It's impossible to find two that are identical; even shop-bought rigs have imperfections, all overcome during the building phase. On top of that, transferring heat away from your cherished hardware via water is vastly more efficient than using a traditional air cooler. Although they do essentially work on the same basic principle (more surface area = more cooling potential), you can move that heat away from your components far faster, and dump it into the radiators far quicker, than with air cooling. Couple that with the astronomical level of surface area available in a 240mm rad compared with an air-cooled tower, and we're on to a winner. Then, of course, there's the noise aspect. More radiators and larger surface areas require less aggressive fan profiles to dissipate that heat. What does that mean? Sub-1,000rpm fan speeds, even under load, so you'll end up with a deathly silent powerhouse of a machine. Workstation or gaming system, these babies always run quietly and smoothly.

CHOOSING YOUR STYLE

Hard-pipe builds have boomed in popularity recently.

WHAT'S THE FIRST THING you need to think about when planning your loop? Tubing. You need to decide which type is right for you. You have four options. There's the classic soft tubing, which is easy to manipulate, cheap, and you can get away with just using a pair of snips or scissors and some standard compression fittings to do the job nicely. Then, of course, you have the hardline variants...

There's acrylic: clear and crisp. The first hardline builds were created entirely using this type of tubing. Unfortunately, it's very brittle and can snap easily. It's also a little more sensitive to heat when you're bending it, and has a nasty habit of bubbling up if it's heated too much.

Then there's PETG, acrylic's successor. PETG contains a small amount of plastic in its chemical makeup, ensuring that it doesn't shatter. Instead, it crushes, ideal for the safety and integrity of your system. It is a little pricier than standard acrylic, but it's well worth it in our opinion.

You'll need the same equipment to use these types of hard tubing: a heat gun for bending, a chamfer tool to sand down the edges, a silicon tube insert to stop the tubing from caving in on itself during your bends, and something to form your bends around if you're not fond of doing it by eye. We'll go into more detail on that later.

Finally, there's copper or brass tubing. This is opaque, and although it sounds less workable than the other hard-pipe options, it's the easiest of the three. All you need is a mini pipe bender, a chamfer tool, and job done—no need for heat guns.

Then you have to pick the diameter that's right for you (ID/OD stands for inner diameter and outer diameter). For hard tubing, the common ODs are 12mm, 14mm, and 16mm. For soft tubing, you're looking at 13mm, 16mm, and 19mm.

We settled on using PETG hard tubing, provided by EKWB. It's by far the cleanest and safest material, and the clear style will help us show off our white coolant. To match our ITX chassis, we went with 12mm OD—its elegant size makes it easy and small enough to work with in such a cramped environment.

Red, red, so much red—red everywhere!

AESTHETIC DECISIONS

ONCE YOU'VE CHOSEN what style of piping you're going with, you need to think about the general aesthetics of your build. This'll mostly come down to personal taste—however, there are a few points you should watch out for. Mostly, these revolve around the coolant itself. Over time, certainly if you're not maintaining your water-cooled loop, the coolant inside your system can "gunk up," proving troublesome to move. On top of that, certain coolant colors (looking at you, red) can be quite difficult to shift from the inside of radiators and the like. Say, for instance, you wanted to change from a clear red coolant to a white pastel—you might just end up with a pink system, even after several attempts at flushing your radiators. For our system, we're going with a simple black and white theme. The contrasting tones should work well together to draw attention to the vital components within the build—namely the GPU and the CPU blocks—and the dark solid black blocks should stand out stark against the white coolant within.

CASE SELECTION

THE NEXT DECISION you need to make is what hardware you're looking to cool, and which case you're going to house everything in. Not all chassis are designed with water-cooling support in mind. Always double-check that the case you want to use has support for the necessary radiators and hardware you'll need to mount. On top of that, you'll need to double-check radiator sizing. For instance, we decided to use NZXT's ITX Manta chassis—although gorgeous, and capable of holding dual 280mm radiators, we weren't certain how thick a radiator it could house in the roof. After a quick discussion with NZXT, we found out that we could only fit a slim radiator, measuring less than 35mm in depth, at the top. Usually, these specs are included on the manufacturer's website, or in reviews, but if not, your best bet is to get on the phone and ask customer support about it.

MYTH BUSTING

Radiator Sizing

How many radiators do you need for your fancy, swanky build? The usual rule of thumb is that, on average, you want one 120mm radiator for each piece of hardware you're trying to cool. And if you're looking to overclock, you should double that to 240mm for each component.

Loop Configuration

Another myth to bust is loop orientation. We received a lot of queries about our last water-cooling feature relating to the position and orientation of our loop. Particularly that our GPUs went straight into the CPU, then into the radiator. The theory being that there should be a radiator between the two. In reality, your loop orientation doesn't matter. Once you close off the loop and introduce pressure to the system, the overall temperature of the water won't change at any given point within the system. What's important is that your pump is gravity-fed by a reservoir, just to ensure it never runs dry.

Fan Selection and FPI in Radiators

By now, no doubt you'll be aware that the cooling world has two types of fan for use inside your PC: static pressure fans or airflow optimized fans. Static pressure fans (Corsair's SP120 or Noctua's NF-F12, for example), are designed to work primarily with air cooler towers, and radiators with a high fin density. Fin density, usually measured in FPI, indicates the number of fins dissipating heat per inch within a radiator. The higher the FPI, the more benefit you'll get from utilizing a static pressure fan. However, this has diminishing returns—once you get below around 10 FPI, you really won't gain much by using static pressure fans over their optimized airflow equivalents, short of a slightly more expensive bill.

FITTING SELECTION

WHAT'S NEXT? Well, once you've decided on what hardware you're cooling, which radiators you're using, and what type and size of tubing you're utilizing, your next step is to choose the right fittings. For hard-piped loops in particular, it's important to understand which fittings you need to make your overall build experience as painless as possible. So, let's discuss your choices....

SOFT TUBE FITTINGS

FOR SOFT TUBING, there's no excuse not to use compression fittings. Barbs used to be the way forward. Secured by outward pressure, cable ties, clamps, and lots of love, barbs were often the only way to water cool. Fast-forward five years, and we now live in the age of compression. Using a barb-like interior connection and a compression outer ring, these effectively and safely secure your tubing hassle-free.

HARD TUBE FITTINGS

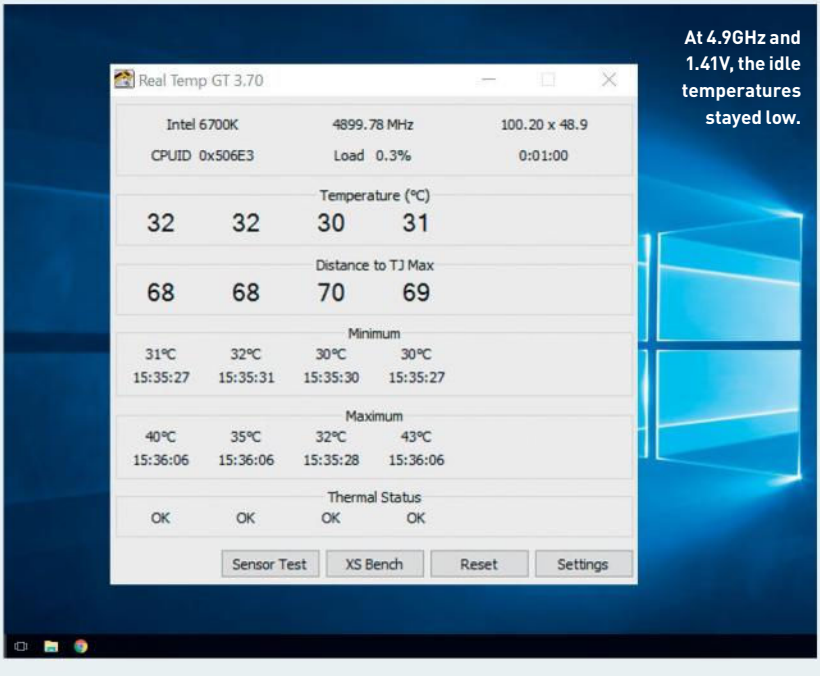
FOR HARD TUBING, you have two options: the now-aging push fittings, which hold the tubing in place thanks to pressure and o-rings, or specially designed hard tubing compression fittings, which follow a similar method as the push fittings, but with a secondary compression layer on top. Again, they're far more secure, but also far more expensive than their push counterparts.

ANGLED FITTINGS

THEN THERE ARE angled fittings. Predominantly used in the hard tubing world, these fittings, often rotary, come in 33, 45, 66, and 90 degrees, allowing you better expandability and maneuverability within a build. But that's not all, either. On top of that, you have stop valves, fill ports, rotary and non rotary valves, bridges, and plugs. All providing useful advantages, enabling the modder to skip out on troublesome predicaments that might otherwise arise during construction.

PERFORMANCE AT STOCK

PERFORMANCE FOR our hardlined water beauty was stunning. But we were expecting it to be—take a glance at our component justification on page 32 and you'll understand why. But that's not important. What is important are temperatures and noise control, and for our little Manta, that wasn't going to be a problem. At stock, our idle temperature for the Intel Core i7-6700K rested at a cosy 23 C, with the AMD R9 Fury X following close behind at a slightly warmer 30 C—nothing to be sniffed at. Noise is difficult to measure in our busy office, but there was barely a hum emanating from the Manta. Noctua's NF-F12 IPPC, although quite rowdy at 2,000rpm, dominates the field of noise control. All four of our system fans are plugged into the integrated fan hub on the back, along with the pump, then straight into the CPU fan header, ensuring that unless the CPU reaches 65 C, they won't operate at higher than 20 percent of their rated speed.



At 4.9GHz and 1.41V, the idle temperatures stayed low.

Practice is the best way to perfect the art.

Make sure you keep heating the outside edge.

It won't go right every time—don't beat yourself up!

BENDING ACRYLIC

NOW YOU'VE CHOSEN your fittings, decided what hardware you're going to cool, and opted for a nice water-cooling compatible case with some beefy radiators, your next step is to install your piping. And, more importantly, configure your bends. Every modder you speak to is going to tell you to do this next part differently. You can either use a 12-inch ruler to gauge how much pipe you'll need, and where to produce your bend, or you can do it by eye. In our opinion, eyeballing it, long-term, will provide you with the better skill set, as opposed to utilizing a trusty 12-inch straight edge. Either way, whatever you do, always start with more tubing than you think you'll need. You can always cut excess tubing off, but you can't add on more tubing after.

First thing you'll want to do is place your heat gun securely facing upward. Next, use the silicon insert and slide it into the tube you want to bend. Some people glaze it in olive oil first, so it's easier to pull out, but that's up to you. Next, you want to set your heat gun to the first setting. The trick is to get the temperature of the tubing just right. You'll want to slowly rotate the piece of pipe, holding each end, about three inches above the heat gun, while moving it slowly back and forth along the point at which you wish to bend it. It shouldn't take too long until it starts to wobble a little. Keep going until you get plenty of flexibility in the bend, while still heating up and down the area at which you're looking to perform your bend. If you're worried it's heating up too fast, lift it up slightly higher. Don't let it get so hot that it melts the acrylic or PETG, and definitely don't let it burn or form bubbles.

Now you've got it hot enough, you'll want to begin performing your bend. You can either use a measuring tool, like we did, sliding the tubing up the tool, and using the guide as a bending agent, or you can do it by eye. Remember, you're trying to get a specific angle here, so if you're not confident with your bending, it's better to use a tool. The trick is to do the bend slowly, while you keep the heat on the outer edge of the bend. We can't emphasize enough just how slowly you should perform your bend—this way, you avoid any unnecessary flat parts to your tubing, and it'll look a lot cleaner.

Once you're happy with your angle, your best bet is to bend it just three to four degrees further round because, once cooled, these tubes have a habit of springing back slightly. Then, move it away from the heat gun, hold it for a moment, blow on it if you like, and wait—you're close to finishing your first bend. Then it's a case of pulling out your silicon insert, and voila—first bend performed!

OVER CLOCKING EXPERIENCE

AS FAR AS OVERCLOCKING GOES, it depends on how lucky you are when it comes to the fabled silicon lottery—we jumped the gun on this build, and went with a pre-binned Core i7-6700K, capable of clocking 5GHz at 1.39V with liquid cooling. Thoroughly enjoyable, utilizing OCCT's Linpack stability test, we maintained a solid overclock with temperatures nestling sub-60 C. The most gratifying aspect of this was the fact that both the pump and the fans were still only spinning at 20 percent of their maximum. Having a system that's so quiet under load is just divine. If you want to see how this hardline build performed at a full overclock, head over to our detailed build guide overleaf for a full set of benchmarks.

Mmm, all those boxes!

COMPONENT JUSTIFICATION

OK, SO THIS ISN'T what you would call a cheap build—we made sure of that during the selection process. The idea was to piece together one of the world's gnarliest ITX systems we could, while still conforming to the NZXT Manta's aesthetic design styles.

With that in mind, there were only a few motherboards we could choose from. For us, the Asus Z170i Pro Gaming was the best choice. We stripped the heatsinks, sprayed the tops with Plasti Dip, leaving the sides stock to allow for good heat dissipation, and took advantage of that M.2 slot hidden on the underside of the motherboard.

Our next port of call was memory—16GB seems to be the norm nowadays, but we wanted to push the envelope on rendering performance, so we decided to double the average, and instead went with a pair of HyperX's Savage 16GB 2,666MT/s C15 sticks.

Next up was the processor, to match the Z170 board. The Core i7-6700K was a no-brainer, but instead of taking our chances with the silicon lottery, we opted to grab ourselves a pre-binned chip, capable of pushing 5GHz with liquid cooling—and, boy, was that worth it.

For the power supply unit, we went with a Corsair AX1200i. Overkill? Most certainly—we only expect to pull 580W from the wall at most. However, this selection was all about noise reduction. We wanted to ensure that, even under load and overclocked, the PSU was only drawing about 50 percent of its capacity from the wall. This way, the fan wouldn't run, and we would benefit from that reduced noise output.

Storage was tricky—we knew we needed to take advantage of that M.2 slot hidden under the board, so we chose Samsung's 950 Pro 512GB PCIe SSD, for the best possible read and write speeds. Being located on the back should help with cooling. For backup storage, we opted for a OCZ Trion 100 1TB SSD—affordable solid-state drive.

For the GPU, we ultimately settled on the Fury X. Being VR-ready, with 4GB of HBM for incredible memory bandwidth, and tasty FreeSync compatibility made it an easy decision. Couple that with the sexy single-slot GPU adapter EKWB provides and, hot damn, is she pretty!

BENCHMARKS

	Closed Loop	NZXT Kraken X61
CPU Idle Temperature – Stock	30 C	**21 C**
CPU Load Temperature – Stock	**48 C**	61 C
CPU Idle Temperature – Overclock @ 4.9GHz	32 C	**27 C**
CPU Load Temperature – Overclock @ 4.9GHz	**66 C**	86 C
Load Temp – Fire Strike	**47 C**	55 C
Rated Fan Noise – 50 Percent	**14.85dB(A)**	18.50dB(A)
Rated Fan Static Pressure – 50 Percent	**1.97mmH_2O**	0.98mmH_2O
Maximum Overclock Achieved	**5GHz**	4.9GHz

Best scores in bold. All benchmarks were performed utilizing their respected cooling methods for the duration of the benchmark, or a single instance of Prime 95 for five minutes. Both maximum overclocks achieved utilizing 1.41V on the CPU core, with the same chip, stability checked using OCCT's Linpack test.

CONCLUSION

SO, IS IT ALL WORTH IT? In our opinion, yes. There's no doubt that it's pricey, but the lower temperatures and overall noise reduction is fantastic. Couple that with such a sexy looking final system, and you're guaranteed to have a good time piecing one of these together. It's more of an ornament than a system, albeit an ornament capable of pushing your hardware to the absolute limits. The temperatures we achieved at the overclocks we did were nigh-on astronomical. Of course, it wasn't as straightforward as a standard build, and there's a lot to take into consideration, whether that's what fittings you're utilizing, or what angles you need to bend, and where to route your cables, but in the end, in our opinion, at least, it was thoroughly worth it. We'll let the picture above speak for itself here.

BUILD IT

ZAK STOREY **STAFF WRITER**

The Miniature Dream PC

A little water cooling here, a radiator or two there, and one hell of a lot of processing power

LENGTH OF TIME: **16–20 HOURS** | LEVEL OF DIFFICULTY: **HARD**

THE PERFECT ALL-ROUNDER

FOR THE PC ENTHUSIAST in today's climate, our work has never been as diverse, as interconnected. Just take a step back for a moment, and consider how much more you do on your system now than, say, 10 years ago. We game, we render, we design, we write, we create, we produce. There's no such thing as the perfect PC, because that would be different for all of us, but what if you wanted to push the limits, to reach beyond the mundane, and to take aesthetic design style and blend it with the craziness of computational processing power?

Well, that's what we're aiming to do here. The idea is to build an insanely powerful ITX system, full of the best and the most brilliant hardware we could find to satisfy all of those different needs. So we can push four million AAA pixels in-game, render 4K videos, record audio, and do our work in complete silence, while retaining a beautiful system you'd be proud to showcase on your desk.

HARDLINE LIQUID COOLING

ULTIMATELY, THIS BUILD was all about encapsulating the feel of our Dream Machines, while condensing it down into a smaller, more affordable form factor. Liquid cooling was our first port of call, and we chose the NZXT Manta to house all of our meaty hardware. The backbone of this rig, we decided, was going to be the Asus Z170i Pro Gaming, thanks to its easily moddable heatsinks and hidden M.2 slot. On top of that we chose an Intel Core i7-6700K pre-binned CPU, clocking in at 4.8GHz, available online from http://siliconlottery.com.

For graphical processing, we went for an XFX Radeon R9 Fury X. The HBM will work a treat, and thanks to some amazing tomfoolery from EKWB's design team, once the waterblock is attached, it's actually a single-slot card.

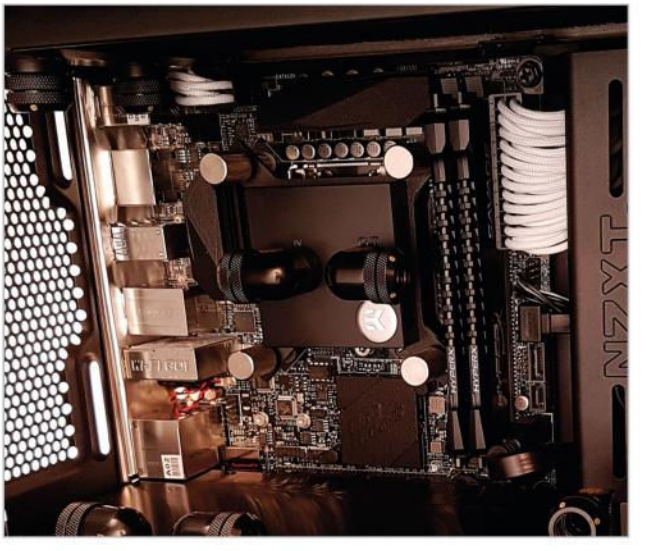
Then we threw 32GB of HyperX Savage 2,666MT/s DDR4 into the mix—brilliant capacity and performance, and it matched our build scheme, too. For storage, we opted for a Samsung 950 Pro 512GB for the operating system, and a further 1TB of storage from the OCZ Trion 100 we still had kicking around the office. More than enough super-fast storage to sink your teeth into.

INGREDIENTS

PART		STREET PRICE
Case	2x NZXT Manta	$280
Motherboard	Asus Z170i Pro Gaming	$165
CPU	Intel Core i7-6700K @ 4.8GHz	$460
Memory	HyperX Savage 32GB (2x 16GB) 2,666MT/s	$194
GPU	XFX Radeon R9 Fury X	$630
PSU	Corsair AX1200i	$310
SSD 1	Samsung 950 Pro 512GB	$333
SSD 2	OCZ Trion 100 960GB	$200
Watercooling & Accessories	Waterblocks, piping, radiators, reservoirs, fittings, coolant, and fans	$1,128
Total		$3700

1 CHOOSING THE PERFECT CASE

THE FIRST THING you have to consider whenever you're about to embark on a water-cooled adventure is what chassis you're going to house your new machine in. The bigger rigs tend to be easier to work in, on the whole, because there's more room inside for you to fiddle around, but for us, ITX was the name of the game. NZXT's Manta looks stunning, and can house a 36mm-deep 240mm rad in the roof, and a meatier 240mm in the front, as well. The only problem was deciding where to mount the res. In the end, we had to drill into the floor, just to the right of the GPU, to add a mounting point for a Phanteks Evolv pump/res mount for our EKWB DDC combi. It still looks classy, and gave us just enough room to maneuver in. Although we're pretty thankful we didn't opt for a longer graphics card here....

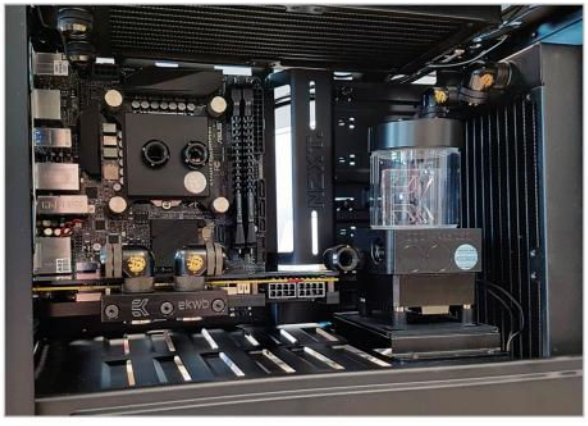


2 SPRAYING THE MOTHERBOARD

GETTING THE PERFECT MOTHERBOARD for this build was particularly difficult. The trick was to find a traditionally oriented Z170 ITX board, with power connectors in the correct place, an M.2 slot, and the whole thing styled in black. Unfortunately, being so choosy left us with very few options. In the end, we decided to compromise a little on the color, and go with the Z170i Pro Gaming. To get the color scheme we wanted, it was a simple case of taking the heatsinks off, masking off everything except the red accents, and then applying a couple of layers of Plasti Dip to hide those color-clashing gaming stripes. Because Plasti Dip is a natural insulator, spraying only over the red accents would ensure we wouldn't be plagued by ridiculously high VRM temps, which we would have ended up with if we had sprayed the entirety of the heatsinks.

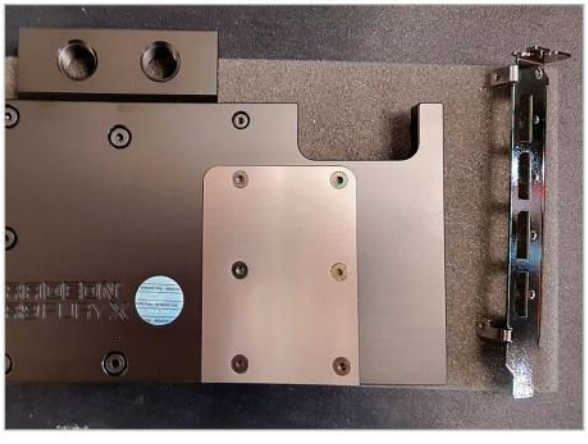
3 PLANNING TUBING RUNS

TUBING RUNS are always going to be tricky to plan in advance—the best advice we can give you is to invest in some angled rotary fittings, especially for hard tubing. They make life so much easier once everything is in your hands. When building any water-cooled rig, you should go through two separate builds. The first to ensure all of your hardware works prior to attaching waterblocks. Then the second prefit just to see where all of your hardware will lie, and what runs you may have to do. In our case, this was incredibly useful, because we learned pretty quickly that our initial idea to mount the combi resevoir to the radiator just wasn't going to work in such a tight chassis.



4 SINGLE-SLOT GPUS

THE DREAM, the ambition, the single-slot, water-cooled flagship card. EKWB provides a stunningly clean single-slot adapter with its Fury X waterblock, enabling the Fury X to be a truly beautiful, compact powerhouse. Couple that with a full cover backplate, and owf! Well, we'll let the photography do the talking. When installing GPU waterblocks, follow the instructions to the letter; there's no messing around here. If you don't make the right contacts here with the block, you can end up short-circuiting your card, or worse. That said, EKWB's EK-FC Fury X block was quite straightforward—the hard part was removing that noisy stock cooler off the original Fury X.



5 SUPER-STEALTH STORAGE

YOU KNOW WHAT we like more than alliteration? Hidden storage. And that's what we managed to achieve fairly seamlessly. The inclusion of an M.2 slot on the rear of the Asus Z170i Pro Gaming is a godsend—although incredibly inaccessible once installed in a water-cooled loop, it's a great way of keeping your M.2 drives cool and out of the way, avoiding any potential eyesores. For our 1TB drive, we simply hid that way down below the PSU cover. Annoyingly, NZXT's SSD mounting points place most SSDs upside down, as far as the label goes, and that's just not good enough for this aesthetic build. Still, it's the performance and capacity we're after—we have enough glamor.

6 FILLING THE LOOP

FILLING ANY LOOP requires forethought and planning; there's always two things you have to consider. Firstly, where your fill port is going to be, and secondly, to ensure that your pump is gravity-fed. Running your pump dry is one of the worst things you can do, as the coolant acts as a natural lubricant for the ball bearing situated in the turbine. To save on size and to ensure this didn't happen, we opted for an EKWB DDC combi pump reservoir; its overall small form factor is a lifesaver for this build, and by mounting it on the bottom of the chassis, we have easy access to the top fill port for inserting our pearly white coolant. Perfect.

1 We actually opted for two NZXT Mantas for this build. We loved the white variant, but the half black/white interior really clashed with the idea we wanted to bring to life here.

2 Although the Manta technically supports two 280mm radiators, you have to bear in mind that the top will only support radiators up to 36mm in depth—we opted for an EKWB CoolStream SE 240mm for the roof, and a PE 240mm for the front of the chassis.

3 Interior lighting is produced thanks to a Bitfenix Alchemy 30cm white LED strip, and two sets of dual 3mm white LEDs—these help bring attention to our hardware, and really make the interior pop.

4 For fans, we decided to opt for four Noctua NF-F12 IPPC variants, spinning at 2,000rpm. The best of the best, these babies are super-silent at a low rpm, incredibly powerful, and—most importantly for Noctua—black.

PERFORMANCE IN AN ATTRACTIVE PACKAGE

FINISHING BUILDING this monster gave us a greater understanding and appreciation of hardline water cooling. As a rookie, it can be daunting, especially when you first start bending your tubing. It's difficult—you have to take a step back, deconstruct your system a few times, and decide what's the best way to run various tubing lines in your chassis. It's definitely a labor of love, but once complete, it's hard to argue that it doesn't look incredible.

But it's not all about how pretty your rig looks, but how she performs when pushed up against that rendering grindstone, right? So, to clarify on our overclocks, we achieved an impressively stable 5GHz on our Core i7-6700K, with 1.41V on CPU core voltage. We kept the 32GB (2x 16GB) HyperX Savage Black DDR4 at 2,400MT/s, because the increased frequency also increased the CAS latency, making it less than worthwhile. And we also left the Fury X at stock, because although it is possible to overclock the Fiji GPU inside, it's incredibly finicky to get stable enough, especially with high CPU overclocks.

All in all, this rig was quiet. Really quiet. Even under load, the most we saw was 60°C, and it still wasn't enough to make the fans kick in. As far as our rendering tests went, we were impressed; 1,074 is nothing to shake your head at, especially for a 4/8 processor. Graphically, the Fury X is certainly a contender—if you're not looking to overclock, it's a solid 1440p card. In *Batman: Arkham City,* we scored a healthy 101fps, and both 4K titles scored frame rates in the high 40s. Dropping anti-aliasing would dramatically improve performance, as it's often unnecessary—certainly at such high pixel densities.

During the build, we came across a few problems, notably positioning the reservoir. If you want to utilize dual 240mm rads in this build, attaching the reservoir to either via a bracket is a nightmare, and on top of that, a combo pump res just won't fit mounted on the center support beam. We had to ghetto mount our EKWB DDC pump on to the center of a Phanteks pump mount from an Evolv ATX, then drill that into the chassis' mid plate.

For liquid cooling, the Manta is an incredible feat of engineering. The fact it isn't stymied by that traditional ITX size, ensuring you get the most out of your liquid cooling, is right up our alley. And as far as utilizing a single PCIe slot goes? Well, most people don't use more than a single GPU, and for good reason: If you have the cash, you go for a better graphics card, as opposed to running SLI or CrossFire, and having to deal with the problems and slow updates associated with that.

BENCHMARKS

	ZERO-POINT	
CineBench R15 Multithread	1,387	1,074 (-23%)
CineBench R15 Single Thread	128	213 (66%)
X264 HD 5.0 (fps)	33.8	24.6 (-27%)
Batman: Arkham City 1440p (fps)	204	101 (-50%)
Tomb Raider 4K (fps)	87.5	46.8 (-47%)
Shadow of Mordor 4K (fps)	70.1	48.96 (-30%)
3DMark Fire Strike Ultra	8,016	3,989 (-50%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-5960X CPU, three GTX 980s, and 16GB RAM. *Arkham City* tested at 2560x1440 Max settings with PhysX off; *Tomb Raider* at Ultimate settings; *Shadow of Mordor* at Max settings.

BUILD IT

ZAK STOREY, STAFF WRITER

A Micro 4K Gaming Box

The question was asked: 4K gaming, microATX, SLI GTX 1080s—can it be done? Here's our response

LENGTH OF TIME: **3–4 HOURS** | LEVEL OF DIFFICULTY: **MEDIUM**

THE CONCEPT

THERE ARE CERTAIN THINGS in the world that must remain as absolute truths. Nothing can exceed the speed of light; peanut butter and jelly sandwiches have to be raspberry flavor; and PC gaming has to be done at 60fps. If these pillars fall, what are we but mere animals? And that brings us nicely to this build —or, more precisely, to one aspect of it. Let's face it, 4K monitors have been around for quite some time now. The increased screen real estate, coupled with a large panel size, tends to lead to a more enjoyable desktop experience. However, finding any graphics setup capable of pushing all of those 8,294,000 pixels more than 60 times a second has been nigh on impossible, certainly in AAA titles. At least, until now.

So, let's get to it. Is it possible, in today's age of 16nm FinFET graphics processors, to build a system capable of maintaining those crucial 60 frames per second at 4K in AAA titles, without fail, in a small enough form factor that you could keep it on your desk? Does SLI make sense in this regard, and what do you need to take into consideration when choosing your microATX chassis?

DESTINATION: 4K GAMING

WHERE TO START with such a unique build? You have two options: Either go all out, drop some cash on an Intel Core i7-6950X, two GTX 1080s, a Samsung 950 Pro, a 1,000W power supply, and a decent chassis—a build that ensures you keep your frame rates high and your credit score low. Or, you can go down the more logical route, something more effective as far as price-to-performance goes—an Intel Core i7-6800K/5820K, and two GTX 1070s or GTX 980 Tis. We thought about it long and hard—no, seriously we did, like for at least five minutes—and then we decided: To hell with logic! An Intel Core i7-6950X and two GTX 1080s it is!

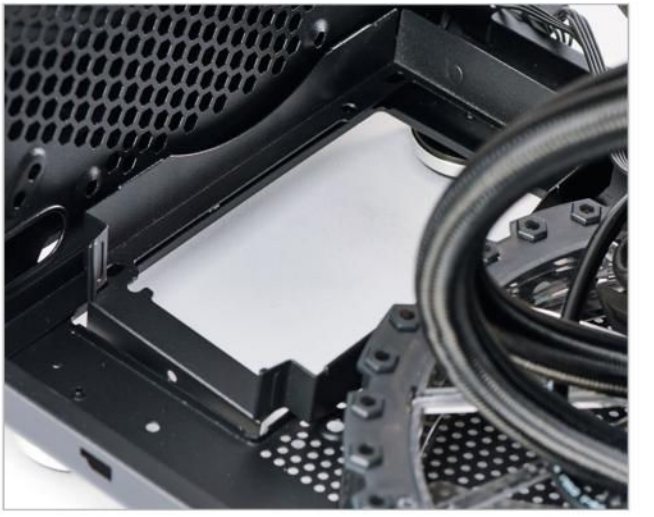
But how do you house all this hardware in a footprint that you can pop on top of your desk? The choice was between a Corsair Carbide Air 240, with a compartmentalized interior and ease-of-use build features, or the more compact and stylish BitFenix Phenom M-ATX. The Phenom won out. The Intel Core i7-6950X is no chilly chip, whether or not you overclock it, and slapping two Founder's Edition cards in there, with blower-style shrouds, gives little breathing room. The Phenom has support for a 230mm BitFenix fan in the floor, and a 120mm fan in the rear, so we can use all the hardware we want without encountering any undesirable temperatures.

INGREDIENTS

PART		STREET PRICE
Case	BitFenix Phenom M	$91
Motherboard	ASRock X99M Extreme4	$184
CPU	Intel Core i7-6950X	$1,660
Memory	Corsair Vengeance LPX 16GB (4x 4GB) @ 2,400MT/s	$80
GPU	2x Nvidia GeForce GTX 1080	$1,398
PSU	Corsair HX1000i	$185
Storage	Samsung 950 Pro	$318
Cooling	Corsair H80i GT, 1x Noctua NF-F12 iPPC 120mm	$113
Total		$4,029

1 GHETTO MODIFICATIONS

THERE'S NOTHING LIKE good old American ingenuity to overcome problems. So, what's the issue here? Well, when building our rig, we noticed that once the motherboard and PSU were installed, the option to install a GPU in the top PCIe slot wasn't possible, as it conflicted with the PSU—it was too long to work with the standard ATX power supply. To get around this, we removed the PSU mounting bracket, then reinstalled half of it by ghetto-mounting it to the bottom of the chassis, running the passthrough cable underneath it, then mounting the PSU to the remainder of the bracket. Although it doesn't look pretty, it resolved an immediate problem. A long-term fix would be to use a Dremel to mount the piece to the chassis, then cut a section out to allow the PSU passthrough cable to sit comfortably.



2 HIGH-BANDWIDTH SLI BRIDGES

WE HAVEN'T HAD the opportunity to talk about Nvidia's latest high-bandwidth SLI bridge, but we have to say, aside from looking spectacularly pretty, we've seen no noticeable difference in frame rate outside of margin for error, even at 4K. One thing this mighty pretty SLI bridge does do, however, is ensure that your GPUs don't have the structural integrity of a chocolate soufflé. Once you've got this installed, the two cards are rock solid, and in an inverted build like this one, that can be incredibly handy, especially if you're transporting your machine around. On the other hand, they're quite pricey to get hold of, add very little with regard to performance, and, considering this chassis is windowless, it may be worth leaving the bridge out in favor of spending the cash elsewhere.

3 AIO COOLERS AND MEMORY WOES

ALTHOUGH THE PHENOM'S SPEC page states that it supports a single 140mm fan in the rear, that doesn't mean a liquid cooler will fit. This is due to the radiator being bigger than the fan, particularly the reservoir that you can see below it. If you try to opt for a 140mm radiator, such as the NZXT Kraken X41 (our first choice), you're going to run into issues mounting it to the chassis. Then there's the fan conundrum; in this case, we opted to install it in a pull configuration, to maintain a positive pressure system, while also making it far easier to mount. It's also worth noting that we used low-profile memory—anything higher and you're going to struggle to install that rear I/O cooler. And if you're thinking of using an air tower, by blocking that airway by the 230mm intake fan, you'll end up stifling your GPUs.

4 EXTRA INTAKES

HERE'S ANOTHER PRIME EXAMPLE of an opportunity to get some modding in. What would be perfect here would be two additional 120mm fans running as intakes, blowing cool air on to the two GPUs. Unfortunately, with the vent off, it's just a touch too cramped to install two 120mm fans, because most are too deep to install with the dust filter as well. What you could do is either opt for two slim 120mm fans (Silverstone's Tek Professional Slims come to mind), or mod a new top fan cover with an extra half inch or so of height, to compensate for normal-sized fans. That way, you could drive even more air into the chassis, keep those two blower coolers well fed, and improve your overclocking headroom in the process.

5 CABLE MANAGEMENT? WHAT'S THAT?

IF YOU'VE TAKEN A LOOK at that last image, you've probably decided we're really lazy, and couldn't be bothered to tidy up our cables. On the contrary—due to the orientation and positioning of the PSU in this chassis, there's very little room for us to move those cables around. It is possible to route some of the cables behind the motherboard tray through clever planning, but the vast majority of them need to sit on top of the PSU. Fortunately, it's not too much of an issue, because this is a windowless chassis, and as long as you're not blocking your 230mm intake fan on the bottom, all will be well in the world of thermals.

6 SIDE PANEL I/O

BITFENIX HAS TAKEN an unusual route when it comes to the front I/O panel. Instead of embedding it on the top of the chassis, it's on the motherboard-facing side panel. The problem with this is that most of the front I/O connectors on motherboards are located just under the uppermost GPU, so in an SLI system, you'll have to plug the "front" panel I/O in before you install the final GPU. Fortunately, there is a way around this. If you take a look at the side panel, you'll notice the front I/O and HD audio are connected via a white plastic locking port—pull them out of the socket here, plug the connector ends into the headers on the motherboard, install your GPU, get your system all wrapped up, then plug them back into your side panel, and lock up shop. Job done.

1 **This was one of the trickier builds to work in with regard to cable management. You might notice it becomes particularly cramped when installing both the 8-pin EPS power (see bottom-middle) and the 24-pin—an easy trick to unhook these is to use a key. Simply wedge it down from the top of the notch, press down, and pull the cable up and out.**

2 **There's going to be a fair amount of tension on that tubing when you're installing the AIO liquid cooler. But don't worry too much about it—Corsair assured us that the H80 is designed to take this level of strain, thanks to the cable braid that surrounds those water funnels.**

3 **The advantage of having a large fan like this is that it's exceptionally quiet, relatively speaking, certainly in contrast to 120mm or 140mm fans. Couple that with the insane amount of airflow it can draw in, and you're all set. Just remember to remove the solid dust filter located below before you install it.**

4 **What we would suggest if you are looking to build a 4K rig with two graphics cards, is that you opt for either a low-end X99 processor (the Intel Core i7-5820K or 6800K come to mind), or one of the latest Skylake processors.**

4K GAMING ACHIEVED

THE IDEA was to build a system capable of gaming at 4K, that you could fit on your desk, and keep out of the way of pesky ungrown humans and furry animals. It's an admirable pursuit. Over the next two or three years, it's likely we'll see 4K gaming becoming more prevalent, certainly with the advent of DisplayPort 1.3 and 1.4, and 120Hz-plus monitors bounding toward us at breakneck speed. Hopefully, 60Hz panels will drop to 1080p levels—at least, that's the dream—enabling us to appreciate the glory of those high pixel density displays.

Did we achieve our goal? Sort of. Two GTX 1080s in SLI certainly make 4K gaming a reality, but it comes with its caveats. Power draw is the first issue. Even though Nvidia utilizes the 16nm FinFET process, the overall draw of both these cards is still significantly higher than the pinnacle of Maxwell, aka the GTX 980. Then there's the SLI profiles. Not all games support multiple GPUs, as it's mostly down to the devs to code that in, and even those that eventually do, most don't support it at launch. After all, the devs want to get their games out on time, and with the vast majority of gamers not taking advantage of two-way SLI or CrossFire, it's not a priority.

Then we have to deal with temperatures. Although we kept them within reasonable parameters (only three degrees higher than our recorded maximum on our test bed) with a tweak of the fan settings and some ingenious cooling layouts, it may not have worked as well with open-air-style coolers.

As for performance, this little beauty did admirably. At 4K, we saw an average of 71fps in *Far Cry Primal*, 64fps in *The Division*, and 35fps in *Rise of the Tomb Raider*, all on the absolute cutting edge of graphical settings at 4K. One thing to note, however, is that with SLI enabled, *Far Cry Primal* at 1080p scored 20fps less than with it disabled, proving once more that SLI is not perfect. In computational benchmarks, the Intel Core i7-6950X didn't disappoint, scoring an impressive 2,155 points in Cinebench, and 8,758 in PCMark 8 Creative.

Regarding the build process, there's no denying it was a nightmare. But that's always going to be the case with the vast majority of microATX and ITX systems. There's little room to move in such a small chassis, and cable management is a problem. In hindsight, it would have been much nicer to work inside the Corsair Carbide Air 240, as it is compartmentalized, which allows for cable management and better airflow. However, the Carbide Air 240 is relatively new, while the Phenom is less so, so hopefully, in the future, we'll see BitFenix produce something of a similar caliber, if not better.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	987	2155 (118%)
Cinebench R15 Single Thread	196	153 (-21%)
TechARP's x264 HD 5.0.1 (fps)	21.93	34.39 (57%)
PCMark 8 Creative	7,675	8,758 (14%)
Rise of the Tomb Raider	41	91 (122%)
Far Cry Primal	76	76 (0%)
The Division	78	148.4 (90%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM.
All games are tested at 1080p on max settings, with HD texture packages installed.

BUILD IT

ZAK STOREY, STAFF WRITER

Everyman's Gaming Machine

Here's an ideal mid-range system, designed to get you the best possible 1440p experience

LENGTH OF TIME: **2-3 HOURS** | LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

WHAT GOT YOU into PCs in the first place? Can you remember? Odds are it was gaming. And that's exactly what this build is all about. Getting back to our roots, piecing together a rig that is centered around a respectable GPU and a gaming workhorse of a CPU.

For the previous three generations of Nvidia GPUs, the premium best-value option from team green has centered around the x70 series of cards. Whether that's the GTX 770, 970, or now the 1070, these graphical processors have always pushed their respective target resolutions to the very pinnacle of frame rate success. Then, of course, there's your choice of processor. The general rule of thumb has been that unless you're making money of out of Hyper-Threading, you simply don't need it. The Core i5 processors have valiantly held aloft the heads of many a talented gamer, those looking again for the best-value premium processor at exactly the right price.

THE GAMER'S DREAM

LET'S CUT TO THE CHASE. This little beastie of ours houses the aftermarket MSI GeForce GTX 1070 Gaming X, overclocked at stock to provide just a touch extra boost clock—far quieter, cooler, and gamier than its Founder's Edition compatriot. On top of that, we've coupled it with Intel's Core i5-6600K, clocked at a lovely 4.4GHz. The legendary quad-core i5 series processors have been at the heart of many a gamer's rig since the launch of Sandy Bridge, way back when, and not a lot's changed. With an exceptional overclocking range, and strong single-core performance, is it any wonder that these are still the gamer's processors of choice? To round all that out, we went with an Asus Maximus VIII Formula motherboard, 16GB of Crucial Ballistix Elite DDR4 @ 2,666MT/s, a Kingston HyperX Predator 480GB PCIe SSD for the OS, plus crucial games and programs, and an additional 960GB of SSD storage in the form of the Crucial BX200. All sitting snugly inside the Phanteks Enthoo Evolv ATX Black tempered glass chassis, which is an absolute dream to work in—roomy and flexible.

There are a few little extras—this time around, we opted to stay with the stock Phanteks fans in the roof and rear of the chassis, still utilizing two Noctua NF-F12 iPPCs for the mighty Corsair Hydro H100i V2.

INGREDIENTS

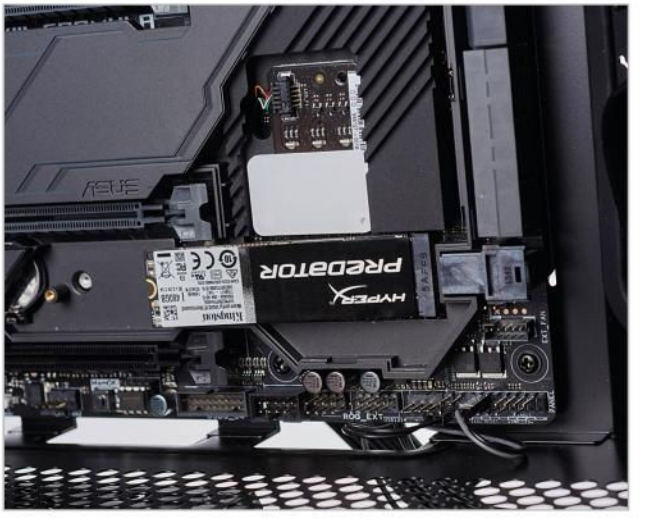
PART		STREET PRICE
Case	Phanteks Enthoo Evolv ATX Glass	$190
Motherboard	Asus Maximus VIII Formula	$348
CPU	Intel Core i5-6600K @ 4.4GHz	$220
Memory	Crucial Ballistix Elite 16GB (2x 8GB) @ 2,666MT/s	$75
GPU	MSI GeForce GTX 1070 Gaming X	$469
PSU	Corsair HX1000i	$185
Storage 1	Kingston Predator 480GB M.2 PCIe SSD	$300
Storage 2	Crucial BX200 960GB	$240
Cooling	Corsair Hydro H100i V2 plus 2x Noctua NF-F12 iPPC 120mm 2,000rpm fans	$141
Total		$2,168

1 SMUDGES, SMUDGES EVERYWHERE

WE ABSOLUTELY LOVE this chassis. What Phanteks managed to achieve with the Evolv ATX was simply incredible, especially for those wanting to build a clean, good-looking system with an AIO cooler keeping it safe. The room to move and the quality of the aluminum panels is simply amazing. One thing to bear in mind, however, if you do opt to get the tempered glass version we've featured here, is that those glass panels will smudge. We don't want to put you off; it's just a warning—this baby will require a ton of spit and polish to get it into shape after you're done. It's almost worth wearing gloves, just to avoid getting your grubby fingermarks on that panel. The aluminum panels do stain a bit, too, but it's nothing a little isopropyl alcohol or window cleaner won't get rid of.

2 HIDDEN PCIE SSD

YOU SIMPLY CAN'T BEAT PCIe SSDs. Even the ones at the cheaper end of the spectrum—such as this 480GB HyperX Predator drive—easily outclass even the most hardy of SATA-based SSDs. So, what's the problem? Well, they're hardly the cleanest-looking components. Even Samsung's ever-popular SM951 editions tend to house a green PCB, and despite the black styling of the Predator, and the likes of the new 950 Pros that have recently been released, they're just a little too garish for those looking to build a super-clean system. Say hello to the Maximus VIII Formula's secret weapon, then. A simple, small Phillips screw and a quick yank later—wham! Super-stealthy, hidden M.2 storage under the Formula's Thermal Armor. The word "classy" doesn't quite cut it.



3 CPU COOLER CABLING

THERE ARE USUALLY two ways to get around messy CPU block cables stemming from those mighty AIOs. Either you luck out with your case/motherboard combo, and can stretch them far enough out the way, or you can tie them up into a little nice loop. Unfortunately, that didn't work for us here, and it ruined our style a little. So, to compromise, instead of wrapping the cables around in a loop as usual, poking out from the sides of the DDR4, we opted to actually wrap them around one of the Hydro's mounting thumbscrews. Is it perfect? No, but it's a lot better than it was.

4 CABLE MANAGEMENT NEEDED

THERE'S A COUPLE OF NIFTY features that the Evolv ATX employs to help keep your cables tidy round the back of the chassis. Those Velcro straps are godsends, and mounting SSDs on the rear of the motherboard tray is a stroke of genius. Couple that with a simple fan hub controlling up to eight fans, and we're on to a winner. Only problem? Well, there's that tempered glass to deal with yet again. Although it's smoked, you can see through it, so your cable management will certainly need to be on point to ensure your rig looks as respectable round the back as it does at the front.

5 POSITIVE PRESSURE

WE CAN'T EMPHASIZE this enough. Positive pressure, positive pressure, positive pressure. Trust us—you'll thank us later. Having a positive pressure fan setup improves internal case temperatures, and helps reduce the amount of dust build-up inside your chassis, meaning it's a lot easier to clean. Thanks to the majority of our fans blowing air into our system, sucking cool air in through dust filters, any air inside the chassis is exhausted and pushed out of the unfiltered areas and gaps, stopping dust from entering your chassis when the system is running. Neat, huh?

6 INSTALLING THAT MIGHTY GPU

WARNING: This is not how you install a GPU; this is how you take a photo of installing a GPU. It turns out, that's quite difficult to make look good. Ensure you remove your PCIe cover on the bottom of the card, remove the two screws holding the PCIe brackets in place, and gently slot your card into the PCIe slot. Then use the same screws to tighten the GPU down, plug in your eight-pin and six-pin power, and voila—you're all done and ready to game. It's rare to have any problems when it comes to installing GPUs; however, some of the heavier cards—Zotac's Arctic Storm comes to mind—might come with a reinforcing bracket or pole to ensure the weight of the card doesn't put too much strain on the motherboard, and also to avoid GPU sag.

1 **If we've said it once, we've said it a thousand times: custom cable kits always make a build pop. We'd have loved to have gone with some custom sleeved cables here. If you haven't got the time, there are plenty of modders out there happy to sell you custom sleeved cables. Even Corsair sells them; alas, without cable combs to keep them tidy.**

2 **Radiator orientation is something that you'll constantly get criticized for. Apart from fan orientation and pressure systems, it's one of the most controversial and heavily debated topics on the Internet. In our experience, however, whether you mount in the roof or the front of the chassis really doesn't make a huge difference, especially in a positive system.**

3 **One problem we had with this particular combination of motherboard and case was with the USB 3.0 front panel connectors (just south of the 24-pin ATX power). As you may have noticed, there's no grommet directly opposite it, and because the USB 3.0 front panel has such a stiff cable, we opted to not plug it in at all. A little inconvenient, but not the end of the world.**

4 **We'll admit that the 1,000W PSU is overkill for this build. Especially considering how quiet even Corsair's RX series power supplies are. A Corsair RM650 would've been plenty, even with those mighty overclocks chunking away at the Intel Core i5-6600K and GTX 1070.**

THE GAMER'S POWERHOUSE

THE TRUE BEAUTY of personal computing lies within the community. Shocking? Think about it for a moment. Ask yourself, what is a "good" PC? It's no easy question. After all, you could drop $20,000 on parts, and piece together a masterfully crafted silicon monster capable of rendering the world asunder with its mighty 48-thread processors. But is that a "good" PC? To us enthusiasts, maybe. But to the 12-year-old setting his sights on his first gaming system, or the sound engineer looking for a new recording studio setup, or the pensioner after an HTPC for the den? Probably not.

And that's what's so fantastic about our community—there's never a right answer when it comes to component selection. It depends on what you need the system to do, what games you play, what programs you use, what resolution you run at.

With this machine, however, in our eyes, it's one of the best mid-to-high-end gaming PCs you could set your sights on. There's a few things you could change to make it cheaper, or increase cost and performance, but for 1080p and 1440p, it's nigh-on perfect. It's crisp and clean, the Phanteks Enthoo Evolv ATX chassis was fantastic to work inside; it did have a habit of picking up fingerprints, but that's par for the course with glass and aluminum. Cable management was excellent, and the extra mounting points for hiding SSDs were neat.

As far as the system goes, it does lean a little on the extreme side of component selection. It would be possible to achieve the same performance with, say, an air cooler, or a lower specced card. MSI's Gaming X variant of the GTX 1070 is around $20 more than even the Founder's Edition, but you'll still be able to get a GTX 1070 with a reference PCB and a dual-cooler for around $430 once stock makes it to market. Couple that with a 650/750W power supply, and potentially a smaller PCIe SSD, and you're on to a winner real fast.

As for performance, we were impressed with the Intel Core i5-6600K. Although we didn't push it to its absolute limit, that impressive overclock, up to 4.4GHz, was more than enough to keep the frame rate gods happy. And it wasn't too far behind the Core i7 in our zero-point. Pretty nifty. The big winner here was the GeForce GTX 1070. What a card! For value for money, it's the king of cool right now. Again, we didn't overclock it, but it's possible to get 2,000MHz-plus on this beauty, for some impressive gains on the average and minimum frame rate front. The HyperX Predator let us down a bit, with read and write speeds comparable only to that of a two-disk RAID 0 setup. That aside, we ended up with one nippy system, more than capable of some thoroughly enjoyable gaming at 1440p.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	987	727 (-26%)
Cinebench R15 Single Thread	196	189 (-3%)
TechARP's x264 HD 5.0.1 (fps)	21.93	17.95 (-18%)
PC Mark 8 Creative	7,675	8,937 (16%)
Rise of the Tomb Raider	41	57 (39%)
Far Cry Primal	76	93 (22%)
The Division	78	87 (12%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM.
All games are tested at 1080p on max settings, with HD texture packages installed.

BUILD IT

ZAK STOREY, STAFF WRITER

The Goliath Workhorse

Intel and Nvidia join forces to power one gnarly rendering machine

LENGTH OF TIME: **2-3 HOURS** | LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

WHETHER IT'S 900bhp hypercars or the full, unbridled fury of an Atlas V rocket heading into low-earth orbit, there's something about insane power that inescapably draws all human beings toward it. Breaking barriers is in our nature. It's what our species does best. Although it's rarely cost-effective or realistic, having access to the ludicrous is something the vast majority of us covets.

Without a doubt, then, we can safely say this machine has a hint of craziness about it. Let's be honest, you know why we pieced this machine together: To show off the incredible madness held within the depths of each of those wily sub-16nm high-end processors.

So how do we justify a machine like this? As a 4K gaming workstation. That's our excuse for putting this monstrosity together. There's no fancy custom loop water cooling found here, no complicated setups, or anything along those lines. Just simple plug and play hardware, and a hell of a hit to the old wallet. But if you need it, you need it.

A RENDERING GIANT

HOW DO YOU piece together a leviathan like this? Well, the CPU is always a good place to start. The Core i7-6950X is Intel's first deca-core processor, and coming in at a respectable (ha, who are we kidding—it's insane!) $1,569, it's the backbone of our PC. We coupled that with Asus's updated X99-A II motherboard. Although not as high-end as its deluxe series, it still has all the features and expandability options we were after.

We had to couple that with 64GB of Corsair's finest, a fully digital 1,000W power supply in the form of the HX1000i, and a case: a Corsair Carbide 400C. This mid-tower chassis has ample room for dependable airflow, and its clean, straight lines ensure we'll be getting a build that looks as classy as its price tag. We did consider the 600C, but that inverse layout has caused enough controversy since its release. For storage, we opted for 12TB of Western Digital's Black drives, and a single 1.2TB PCIe NVMe Intel 750 SSD for the OS.

But wait! We can't forget about that pixel-rendering beauty sitting in the middle of this beauty: the GTX 1080. The world's most powerful single GPU at the time we built this PC. Although a bit of a price hike in contrast to the GTX 980—even if we were using the non-Founders Edition—it's still the biggest and best graphical kid on the block. Our only regret? We wished we had two for this build.

INGREDIENTS

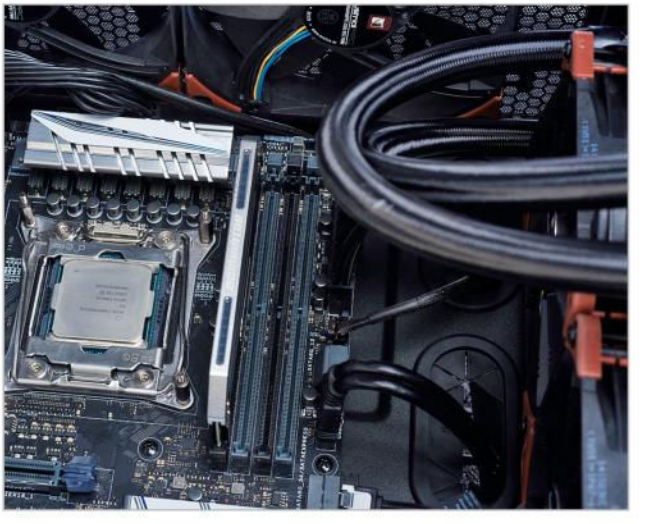
PART		STREET PRICE
Case	Corsair Carbide 400C	$80
Motherboard	Asus X99-AII	$250
CPU	Intel Core i7-6950X @ 4.3GHz	$1,569
Memory	Corsair Dominator Platinum 64GB (8x 8GB) 2,400MT/s	$470
GPU	Nvidia GeForce GTX 1080 Founders Edition	$699
PSU	Corsair HX1000i	$185
Storage 1	Intel 750 Series 1.2TB PCIe NVMe SSD	$1,018
Storage 2	2x WD Black 6TB 7,200rpm HDD	$550
Cooling	Corsair Hydro H100i v2, 2x Noctua NF-F12 iPPC 120mm, 2x Noctua AF-F14 iPPC 140mm	$198
Total		$5,019

1 CASE WOES

THE 400C is one of the cleanest cases out there, but there's a few things you should bear in mind. Firstly, the power supply cover. To install your PSU, you need to remove that little devil by undoing the three screws on the rear of the motherboard tray. You can then remove the panels and gain access to install the PSU. Unfortunately, there's no other way to install it. Next thing you'll want to do is slide the 3.5-inch hard drive bay across to the left—there are another two thumbscrews located just below the ones from the PSU cover for this. By doing this, you gain extra space to plug in your cables and keep everything nice and organized. One quick tip: Install the PSU and route the CPU power up to the top of the chassis prior to installing the motherboard. It'll save you a lot of effort in the long run.

2 MEMORY AND COOLER

FOR THIS BUILD, we chose Corsair's Hydro H100i V2. We'll be honest, there's not a lot of difference—certainly from an installation standpoint—between different AIO coolers. In this chassis, we chose to install the radiator in the front of the case, ensuring we could pull cool air into the system. Install your radiator and fans before your motherboard; this way, you can route the fan cables where they need to be ahead of time, so there's no hassle later on, trying to install them around your hardware. It's also a smart move to install your memory first, before attaching the heatsink, so you avoid trying to maneuver your DIMMs around the AIO's tubing runs. DDR4's notches are a little more subtle than DDR3, so make sure you line up the notch on the bottom of the DIMM with the notch on the motherboard.



3 PCIE STORAGE

INTEL'S 750 SERIES PCIe SSDs bring large capacities and jaw-dropping read and write speeds to the masses. We took advantage of the 1.2TB variant, coming in at $1,018. If that's a little beyond your budget, you could easily opt for a smaller 400GB version instead, to house your OS and most-used programs. On top of that, if the PCIe card look isn't your jam, or if you fancy running GTX 1080s in SLI, Intel also sells a 2.5-inch variant that connects to the Asus X99-A II via the U.2 standard. And if you really can't be fussed with that, you could opt for a Samsung 950 Pro instead—although it can throttle just a touch under load, this M.2 drive will sit snugly below your graphics card, making placement infinitely easier.

4 INSTALLING 3.5-INCH DRIVES

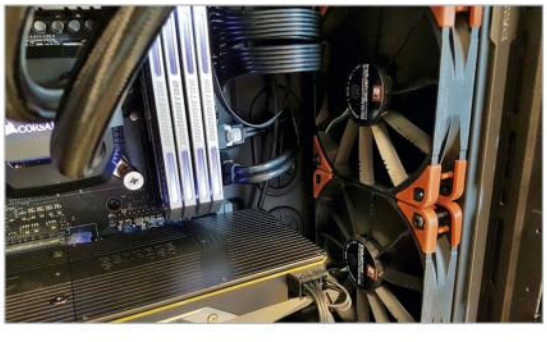
INSTALLING THE two mighty 6TB WD Blacks can be a little tricky, especially as the Corsair 400C is a fairly compact case. Make sure you run your SATA cables from your motherboard first, and ensure you've got a SATA power daisy chain running out of your PSU. Another pro tip is to avoid any of the angled SATA cables—your best bet is to use straight ones, especially if you're occupying both bays. These two Western Digital Black drives boast some insane capacities, ensuring you'll have plenty of redundancy for when the crap hits the fan. We chose to keep them stock, but setting up a RAID 1 or 10 array isn't a bad idea. On top of that, there are three additional 2.5-inch slots on the back of the motherboard tray, if you want to expand your SSD storage even further.

5 KING OF THE HILL

THE GTX 1080 is the pinnacle of single GPU graphics technology at the moment—it kicks absolute ass—but, in relative terms, not a lot has changed since the last generation, as far as installation goes. Plug it in, screw it down, make sure it's got enough breathing room, remember it's a blower-style card—it sucks air in for its coolant, as opposed to circulating it—plug in your power, and you're good to go. The biggest change for us lies in that single 8-pin power connector. Although you could, hypothetically, daisy-chain two GTX 1080s off a single cable, we advise against it, especially considering how power-hungry these babies are. Your best bet is to run two separate cables up to each of your GPUs here, especially if you want to overclock them. And, boy, do these things OC!

6 FILLING THE LOOP

WE'RE A BIG FAN (ha!) of Noctua here in the office—who isn't?—and, for this build, we opted to pump the air around with these little beauties. We chose to run two Noctua NF-F12 iPPC 2,000rpm 120mm fans for the front AIO cooler, pulling cool air through the radiator and into the chassis. And then we have two NF-A14 iPPC 2,000rpm 140mm fans drawing cold air directly in through the roof. There's a couple of reasons for this. Firstly, the horrendous number of cables littered across the top of the motherboard is a nightmare—having them potentially get caught in the fan blades is just going to suck. Secondly, a positive pressure system will make cleaning out your system a little easier in the long run, because all the air drawn into the chassis is filtered, and it's pushed out of all the unfiltered areas. We're all about that system maintenance.



1 **If you really want to get the maximum cooling potential out of this little chassis, you can opt to install a 280mm AIO instead of the 240mm we used. However, it still needs to go in the front, because roof spacing is still just too tight.**

2 **In hindsight, to make this build tidier, we should have opted to run the single 8-pin PCIe power through the grommet to the right of the motherboard/GPU. Although it's absolutely fine coming out of the floor like that, it does look a little awkward and out of place.**

3 **The 400C in combo with this motherboard has plenty of space for an SLI setup. In fact, if you dropped the Intel 750 Series SSD down one slot, and installed a GTX 1080 in its place, you would have zero airflow problems, and one cool SLI powerhouse.**

4 **The only downside with the PSU cover in the 400C is that you can't extend it all the way across. We understand it's there to ensure sufficient radiator support for 360mm AIOs and radiators, but the option would have been nice to hide our HDDs completely, once slid across.**

THERE ARE RENDERING STATIONS, THEN THERE'S THIS

HINDSIGHT IS A WONDERFUL THING. When it comes to building your own rig, it's a vital tool for helping you improve your technique and knowledge for next time. Forethought and planning—that's what's key. For this project, it was all about cable management and studying how the chassis worked.

Take the X99-A II motherboard, for instance. It's a swell update on Asus's last iteration, but there's one problem: the position of the CPU power. As it's direct center, at the top, it makes it difficult to route your EPS 8-pin, especially in combination with the Corsair 400C, as it lacks a third rubber grommet in that central area. So, you end up trailing CPU power from the top-left of the chassis, right across the bottom of your fans. This also manages to cut off access to the three CPU PWM fan headers in the process. It's an immensely tight squeeze to get that EPS power connected when you have two additional 140mm fans, as well.

Even for us, these are problems we couldn't predict. Adapting and overcoming those predicaments—in our eyes, at least—is what makes being a PC enthusiast and building your own system so gratifying.

So, what do 10 cores, 20 threads, 64GB of DDR4, a 16nm FinFET GTX 1080, and over 13TB of storage gain you? One gnarly machine. Overclocking the Core i7-6950X was a doddle. We dropped in the 2,400MT/s XMP settings, switched off SpeedStep, enabled full power phase control, and started upping the multiplier and voltage until we reached a stable point for thermals and system stability. We managed 4.3GHz with a cushy 1.285V on the CPU core. And this is where that deca-core monster shone, racking up an astonishing 2,208 points in Cinebench R15. To put that into perspective, a mainstream Core i7-6700K @ 4.9GHz only manages 1,074, and the last-gen i7-5960X eight-core processor can only hit 1,387 points at stock. Mind blowing. Other than that, we saw an impressive 8,400 points in PC Mark 8's Creative benchmark, and 3D Mark's Fire Strike scored well over 18,000 points—that's a thousand points higher than just utilizing an i7-6700K with the GTX 1080, which goes to show how much those additional cores benefit advanced physics simulation.

This machine is overkill, no doubt about it. It's $5,000-plus of grade A red meat rammed into a sleek, clean chassis. The perfect 4K render workstation, that also excels at gaming. There's only a few things we'd change: a custom cable kit to make this build look incredibly clean, and perhaps another GTX 1080 Founders Edition, with one of those swanky new SLI bridges Nvidia has developed. That would have capped it off as one of the best consumer workstations in the world.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	1,074	2,208 (106%)
Cinebench R15 Single Thread	213	176 (-17%)
TechARP's x264 HD 5.0.1 (fps)	24.6	45.6 (85%)
PC Mark 8 Creative	7,675	8,400 (9%)
Rise of the Tomb Raider	41	65 (59%)
Far Cry Primal	76	102 (34%)
The Division	78	105 (35%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM.
All games are tested at 1080p on max settings, with HD texture packages installed.

BUILD IT

ALEX CAMPBELL **ASSOCIATE EDITOR**

Furiously Fast on the Core i5

It's time to prove you can get some impressive performance from a locked quad-core

LENGTH OF TIME: **1-3 HOURS** | LEVEL OF DIFFICULTY: **MEDIUM**

THE SLAB

IF THERE'S ONE THING we love to have in a build, it's an unlocked CPU. While we don't always overclock our published builds, it's hard to overstate the value that some get from overclocking. There's the "free" upgrade, the satisfaction of customizing and tweaking something yourself, and the thrill of pushing a CPU to its limit.

But not everyone needs to overclock. Most people will never enter the UEFI BIOS, let alone risk voiding a warranty on a part that costs $200 or more. There's another price of overclocking, too, and it's measured in dollars. K-model CPUs are more expensive than their locked counterparts. For a first-time builder or someone on a budget, it's difficult to justify buying a K-model CPU when a locked model does most of the stuff you need it to do.

That's not to say you can't get great performance from a locked CPU. In this build, we set out to assemble a machine that called upon the Core i5-6500, a locked quad-core that's fairly inexpensive. We found that this CPU—the Skylake successor to the Haswell i5-4570—can still get the job done.

ALL IN ON GRAPHICS

ONE OF THE THINGS WE WANTED TO TEST in this build was how a high-end GPU would perform with the humble Core i5-6500. We picked the Asus R9 Fury Strix to push pixels in this build, and complemented the system with 8GB of DDR4 RAM.

We installed our CPU, GPU, and RAM on to an EVGA Z170 Stinger mini-ITX motherboard. The Stinger was one of the first Skylake motherboards we got our hands on, but it's been spending its days on a shelf in the office. We took it from its hiding spot and pressed it into service.

For storage, we turned to one of our favorite SSDs: the 250GB Samsung 850 Evo. With impressive speed and a decent price, the 250GB Evo really is a great base for any PC. This particular SSD was the 2.5-inch model, which we've been trying to wean ourselves away from, opting instead for the M.2 form factor. Unfortunately, not every motherboard supports M.2—while the Stinger does support M.2, it only has room for the shortest of M.2 cards, which we feel is aimed at Wi-Fi expandability, rather than storage.

INGREDIENTS

PART		STREET PRICE
Case	NZXT Manta	$140
Motherboard	EVGA Z170 Stinger ITX	$180
CPU	Intel Core i5-6500	$205
Memory	8GB (2x 4GB) G.Skill Ripjaws 4 Series DDR4-2133	$38
GPU	Asus R9 Fury Strix	$540
PSU	EVGA SuperNOVA NEX 650W 80 Plus Gold	$90
SSD	Samsung 850 Evo 250GB	$88
Total		$1,281

1 BASIC COOLING

ONE OF THE BAD THINGS about getting a K-model Skylake CPU is that you're forced to buy a cooler of some sort. The Core i5-6600K and the i7-6700K both come without heatsinks or fans in the box, so the onus is on the builder to make sure the chips don't overheat. The Core i5-6500 doesn't have that problem.

Intel's stock heatsinks and fans are made by Foxconn (if you look closely, you can see the parts stamped with Foxconn's name). They're far from sexy, but they're effective, low profile, and don't consume much power. And if you're building a PC with a locked CPU, there's really no compelling reason to go out and spend money on a bigger heatsink. Using the stock heatsink and fan also saves time, because installation takes all of about 15 seconds, provided everything is done correctly.

2 ROOM FOR THE BIG GUYS

THE ASUS R9 FURY STRIX is a big card, and using it in a mini-ITX build can sound counter-intuitive. The typical logic that a mini-ITX build means using a small, underpowered card didn't hold true with the Manta.

The front of the Manta actually had plenty of room to spare, which gives us confidence that using a big card such as the Fury Strix with a thick radiator wouldn't pose much of a problem. The front of the Manta comes off easily, allowing for easy fan and radiator mounting.

The two fans you see here come pre-installed, which offers plenty of airflow for the Fury and our air-cooled CPU. It's a good thing, too, because the video card sits just above a partition for the PSU and hard drives. Without plenty of cool air being forced over the card, pulling cool air in from that relatively tight space could be a little tougher.

3 RUNNING CABLES

IF THERE'S ONE THING that will frustrate a builder in a mini-ITX system, it's the location of SATA and USB 3.0 connectors.

When connecting the cables for this rig, we were forced to run them over the top of the RAM DIMMs. While this isn't a big deal, having a clean-looking motherboard compartment is half the reason people buy cases with windows. They don't want to see clutter; they want to see their components in all their glory.

We had to curb our obsessive-compulsive need for a totally clean presentation for the sake of functionality. After all, the machine has to boot, right? And two little cables are far from the worst offenses when it comes to presentation.

It's also worth noting in this photo that the Fury Strix's backplate looks quite nice in this case, and serves to help camouflage the cables slightly.

4 HATS OFF

WE ALREADY MENTIONED that the Manta has plenty of room up front for a radiator and fans, but it would be a shame to leave out what the Manta offers up top. The top of the case is easily removed with a few round tabs found inside. It was only after we tried putting the top back on that we realized that taking off the front panel makes removing the top much, much easier.

The top panel has enough space to accommodate a radiator like that found on the Kraken X61. It looks like there's room to add fans, too. Even if your radiator and fan combo are too big, you can always try hanging the radiator below the bracket and mounting the fans on top (or vice versa).

One thing we noticed here was the lack of a dust screen. It's not the worst thing in the world, and we're forced to wonder where one would be added if it could have one. But having a screen is almost always preferable to not having one.

5 NOT SUCH AN UGLY SIDE

ASTONISHINGLY, THE MANTA accommodates cabling quite well, without the need for excessive tie-downs. If you look closely, you might notice that our big, fat power cables aren't actually tied down to anything. Instead, they sit in a channel that's beveled out into the motherboard compartment. Holes on either side of the channel offer access to the motherboard, while big cables have a roomy place to call home.

The backplate you see actually came from a Gigabyte H170 board. The Z170 board came with a backplate that had arms reaching out to each of the CPU cooler's mounting holes, with a threaded screw hole near the tip of each arm. The stock cooler's prongs couldn't be fitted into the threaded holes, so we had to go with another backplate.

6 STEALTHY STORAGE

THE SAMSUNG 850 EVO we used for storage seems to disappear against the black interior of the Manta. We're just fine with this, because it offers a clean look and doesn't draw attention to itself right away. Upon casual inspection, one could wonder whether the system has storage at all.

The Manta has two mounts for 2.5-inch drives, which sit flush against the panel that's adjacent to the motherboard tray. Using a flush mounting position not only shows off the drives, but allows for an unobstructed path for air (or water tubing) to reach the motherboard.

If builders are looking for a place for a 3.5-inch HDD, the hard drive mount points are located under the PSU compartment partition.

1 **We decided to mount the metal I/O connection cover (not to be confused with the back panel shield) for looks.**

2 **The cabling channel provides easy and clean cabling access to the motherboard and SSDs.**

3 **The Manta includes three fans (two up front, one rear) for plenty of airflow in a stock configuration.**

4 **A PSU partition helps keep the motherboard compartment looking clean and tidy.**

PERFORMANCE IN AN ATTRACTIVE PACKAGE

PUTTING THIS RIG TOGETHER was fun, and we were happy with how it all worked out. The video card looks great behind the Manta's curved window, and the clean layout made the PC something to behold.

Looks aren't everything though, and at the end of the day, the PC has to perform. And perform it did, well, when it did.

There were several instances where the PC would reboot in the middle of a benchmark. While Windows 10 has annoyed users with silent updates and unprompted reboots, we thought it wouldn't happen in the middle of high CPU utilization. We did eventually get through all the benchmarks, so we let it slide. If this were going to be a machine that we'd use day-to-day, we would look for a firmware update for the mobo, and hunt down the culprit.

The scores from the tests were impressive. In our visual tests, the Fury happily pushed pixels out to our screen at a healthy rate, producing playable frame rates in the two 3840x2160 titles. At 1440p, the Fury managed to top 90fps, which is pure gold for gamers with 1440p screens. We're still not totally sold on gaming on 4K monitors; if you're planning on gaming, the smart money is that you're looking at 1440p performance.

In 3DMark Fire Strike Ultra, the Fury managed a score of 3,465. The Oculus Rift recommended spec has a score of 2,596, which easily puts this rig into Oculus-ready territory. Considering that the Oculus-recommended spec calls for an i5-4590 (with a higher clock speed than the i5-6500), we're happy with that.

When it came to timed benchmarks, the 3.2GHz quad-core wasn't going to keep up with the i7-5960X we use as a zero-point. The i5-6500 isn't the CPU you want for computational or workstation tasks, so music producers and graphics designers should go for an i7 instead.

We liked the doors on the Manta, as it had nubs that helped us align the door before securing it. However, NZXT opted for thumb screws that are meant to stay on the doors. While this is great to prevent loss, they assume awkward angles when you're trying to secure the door closed. Having removable screws would alleviate some of these problems.

The Manta is pretty, but it's expensive. The Phanteks Enthoo Evolv we used last month was $70, and offered room for full-size GPUs like the Manta. While the features of the two are different, and the Manta offers more cooling options, it is twice as expensive. It's better suited for builds that plan to do overclocking, so the cooling options can be put to good use. If you're staying stock and locked, the Enthooo Evolv might serve you better.

BENCHMARKS

	ZERO-POINT	
Stitch.Efx 2.0 (sec)	806	832 (-3.2%)
ProShow Producer 5.0 (sec)	1,472	1,811 (-23%)
x264 HD 5.0 (fps)	33.8	13.47 (-60.1%)
Batman: Arkham City 1440p (fps)	204	92 (-55.9%)
Tomb Raider 2160p (fps)	87.5	38.8 (-55.7%)
Shadow of Mordor 2160p (fps)	70.1	44.73 (-36.2%)
3DMark Fire Strike Ultra	8,016	3,465 (-56.8%)

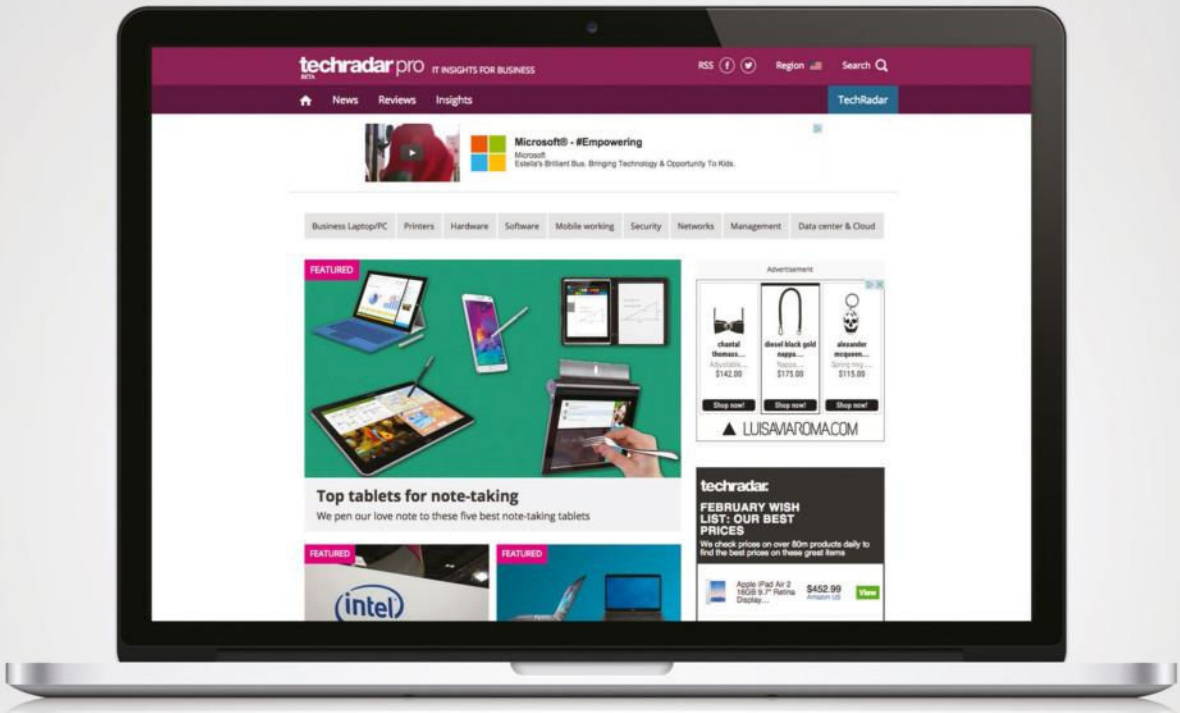
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-5960X CPU, three GTX 980s, and 16GB RAM. *Arkham City* tested at 2560x1440 max settings with PhysX off; *Tomb Raider* at Ultimate settings; *Shadow of Mordor* at Max settings.

Future

techradar.pro

IT INSIGHTS FOR BUSINESS



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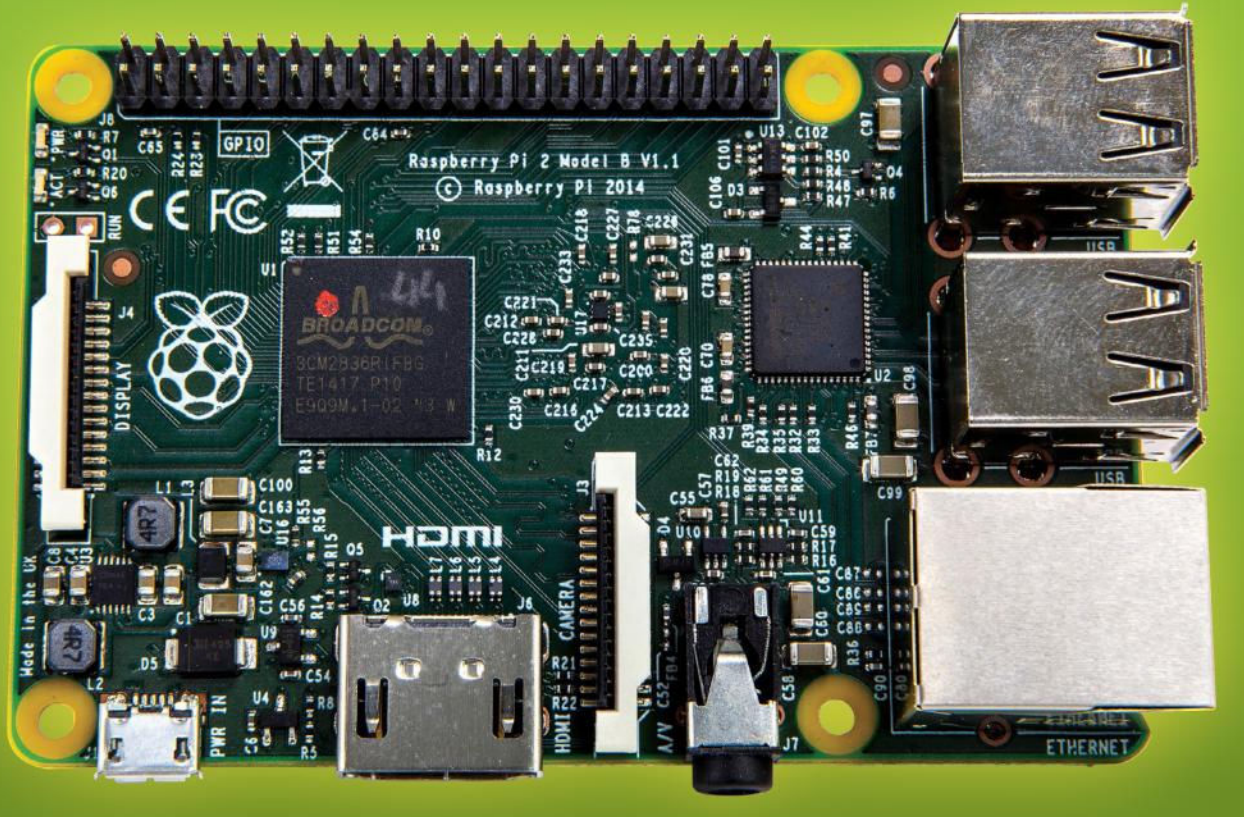

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ADVANCED WINDOWS 10 TIPS & TRICKS

Discover the essential techniques and tools you need to kick Windows into shape

There's no getting away from it: Windows needs almost constant attention. Take your eye off the ball, and it's suddenly clogged up with unwanted files and struggling to keep up, thanks to a pile of software you thought was interesting at the time, but have long since abandoned. Obviously, keeping your PC in good shape is a key part of making it perform well, but while Windows 10 is streets ahead of its predecessors in terms of keeping its demands on your processor, RAM, and other components quite low, there's still lots you can do to fine-tune it, discovering tweaks and settings that ensure it's running at optimum efficiency and speed.

In this feature, we reveal plenty of tips and tricks for making the most of Win 10. We start by giving your PC an efficiency drive—clearing out the rubbish, streamlining startup, and delving into places you may not have thought to cut the bloat and ensure your PC isn't wasting resources on spurious programs and processes. And speaking of bloat, we reveal a handy tip or two for keeping out unwanted programs.

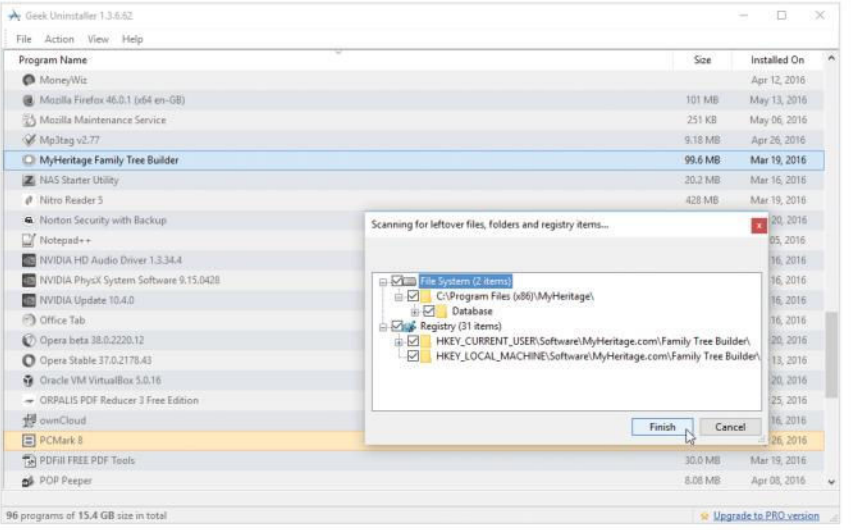
We also show you how to partition your hard drive, and why keeping your data separate is a good idea (it's still no substitute for a backup, though, so keep that in place—check out our guide in the June issue). We then take a closer look at certain parts of your hardware—we remind you why upgrading to an SSD is one of the most effective upgrades you can make, plus reveal some handy tweaks for ensuring it's running smoothly.

If that's not enough, we share some other secrets, too—why portable apps are better than regular installed programs, for example, plus how to tighten Windows 10's lax privacy controls. And if you're about to upgrade to Windows 10, we reveal a path you can follow that enables you to run it alongside your existing version of Windows in a dual-boot configuration. So, get ready to watch your PC take on a new lease of life!

Let's start our efficiency drive with Windows itself. Before you begin, take a System Restore point or drive image—if you take a wrong turn, you can then roll things back and start again. To do the former, type "system restore" into the Search box, and click "Create a Restore point"—verify System Restore has been turned on and correctly configured for your system drive (select it, then click "Configure..." to do so).

Right, we'll begin by giving Windows a good clean. Start by removing any programs and Store apps you no longer need—you'll be surprised at how these can build up over time. These can be removed via "Start → Settings → System → Apps & features," but if you want to go the extra mile, and clear out any leftover files and Registry entries, you'll need to employ the services of a third-party tool.

This is a tricky area—the only tool we've found capable of cleaning out both programs and Windows Store apps is IObit Uninstaller (www.iobit.com), but it's a little too aggressive in attempting to get you to install its full Advanced SystemCare Free suite. If you can live with occasional prompts, use its Powerful Scan feature to clear out redundant Registry entries and leftover files. If you're happy to limit scans to regular programs, try GeekUninstaller (www.geekuninstaller.com) instead, which has the added benefit of being completely portable—no installation required.



Use GeekUninstaller to remove programs more thoroughly.

Once you've cleaned things up, turn your attention to programs and services that start with Windows—these don't just lengthen your boot time, but sit in the background consuming resources, too. You can quickly see which are the most resource-hogging startup programs by opening Task Manager from the Taskbar's right-click menu—switch to the "Start-up" tab (click "More details" first, if necessary), and examine the "Start-up impact" column. Target those High and Medium rated programs you don't use that often by right-clicking them, and choosing "Disable."

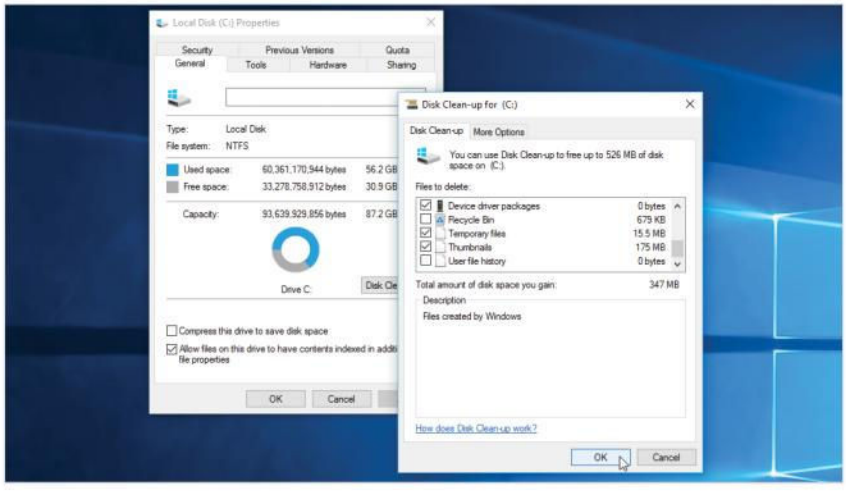
When it comes to Services, you can manage these yourself via the Services desktop app (type "Services" into the Cortana search bar), using the excellent Black Viper (www.blackviper.com) guide to see which Services you can safely disable. If the idea of manually trawling through these doesn't appeal, download the portable Easy Services Optimizer tool from www.sordum.org/8637/easy-service-optimizer-v1-2/. Read the guide carefully, but—simply put—choose "Safe" or "Tweaked" for a quick-fire range of optimizations that will speed up your PC, but may introduce problems. Use the program's own "Service → Reset Service List" option, or a Restore point, to undo your changes if necessary.

Many programs and apps continue to run in the background after you close them—check for a program icon in the Taskbar's Notification Area (click the "^" button to view the full list), or select "Start → Settings → Privacy → Background apps," and flick the switches to "Off" for all or any apps you want to close fully when not in use.

Clean out your drive

The next step is to reclaim wasted hard drive space—even if your drive isn't bursting at the seams, it pays to keep things neat and tidy. Open File Explorer, right-click your system drive (the one marked with the Windows logo), and choose "Properties." Click "Disk Clean-up" on the General tab, and as soon as it opens, click "Clean up system files," to ensure all options are shown. Work through the list, ticking those items you don't want—the biggest gains often come from previous

Find out what's taking up all your drive space with SpaceSniffer.



The Disk Cleanup tool removes some unwanted data, but not all.

Windows installations and system dump files. You can free up space by deleting System Restore points, too, from the More Options tab, but only do this as a last resort, if you're desperate for space.

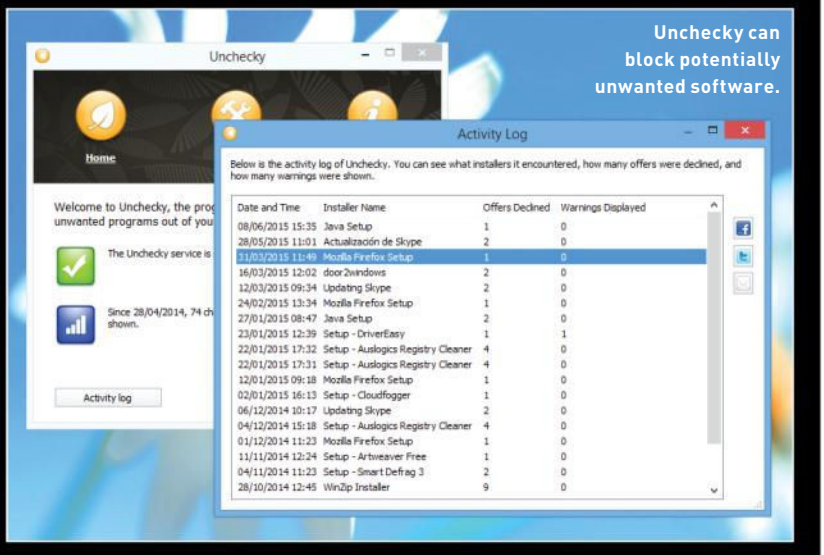
If you want to push the envelope further, download and install CCleaner from www.piriform.com/ccleaner/builds—you'll find a portable version here if you'd rather not install it. The Cleaner component can sweep through Windows, browsers, and application caches to recover gigabytes of files at a time, but it pays to review each item first—you'll lose cookies, Jump List entries, and other useful shortcuts if you're not careful. Click "Analyze," and you'll see a list of what's found—right-click an entry and choose "View detailed results" to see exactly what's getting cleaned, then right-click items you want to keep, and choose

"Add to Exclude list" to protect them from being cleaned now and in the future.

CCleaner has a Registry cleaning tool as well—long story short, leave it well alone. Registry cleaners don't improve performance, and usually introduce more problems than they solve. You might get minor joy using a Registry defrag utility to rearrange the Registry hive files in a similar way to your hard drive, but performance gains are minimal—use Free Registry Defrag (www.registry-clean.net/free-registry-defrag.htm) if you want to go down this route; it works fine with Windows 10.

If you're wondering what's taking up all the space on your hard drive, check out a free portable tool called SpaceSniffer (www.fosshub.com/SpaceSniffer.html), which presents the files on your hard drive using the Treemap concept. Run it as an administrator, to give it access to all your files, then focus in on the biggest folders, to see where the large files are hiding away. It's also worth checking your drive for unnecessary duplicate files—CCleaner can do this for you via its "Tools → Duplicate Finder" component.

One large file SpaceSniffer is likely to identify is hiberfil.sys—it's usually the same size as your RAM, because it's where the contents of your memory are stored when you hibernate your PC. If you never use hibernation (sleep doesn't use this file),


Unchecky
Home
Welcome to Unchecky, the proc
unwanted programs out of you
The Unchecky service is
Since 28/04/2014, 74 ch
shown.
Activity log
Activity Log
Below is the activity log of Unchecky. You can see what installers it encountered, how many offers were declined, and how many warnings were shown.
Date and Time | Installer Name | Offers Declined | Warnings Displayed
08/06/2015 15:35 Java Setup 1 0
28/05/2015 11:01 Actualización de Skype 2 0
31/03/2015 11:49 Mozilla Firefox Setup 1 0
16/03/2015 12:02 door2windows 2 0
12/03/2015 09:34 Updating Skype 2 0
24/02/2015 13:34 Mozilla Firefox Setup 1 0
27/01/2015 08:47 Java Setup 2 0
23/01/2015 12:39 Setup - DriverEasy 1 1
22/01/2015 17:32 Setup - Auslogics Registry Cleaner 4 0
22/01/2015 17:31 Setup - Auslogics Registry Cleaner 4 0
12/01/2015 09:18 Mozilla Firefox Setup 1 0
02/01/2015 16:13 Setup - Cloudfogger 1 0
06/12/2014 10:17 Updating Skype 2 0
04/12/2014 15:18 Setup - Auslogics Registry Cleaner 4 0
01/12/2014 11:23 Mozilla Firefox Setup 1 0
11/11/2014 12:24 Setup - Artweaver Free 1 0
04/11/2014 11:23 Setup - Smart Defrag 3 2 0
28/10/2014 12:45 WinZip Installer 9 0
Unchecky can block potentially unwanted software.

Avoid Bloatware

This guide is all about removing unwanted programs and services, helping free up resources, and potentially providing a noticeable speed boost. But what can you do to stop the flow of bloatware and other potentially unwanted programs (PUPs) from appearing on your PC in the first place? One solution is to purchase a Premium license for Malwarebytes Anti-Malware (www.malwarebytes.org). While the free version can detect and remove PUPs, as well as malware, the Premium version provides real-time protection that blocks them in the first place, often without affecting the rest of the program installation.

If that's too rich for your blood, then Unchecky (www.unchecky.com) is a small program that sits in the background and can detect a wide (if not fully comprehensive) array of adware-infested program installers. It then alerts you to tweak the program installer to de-select any adware options, ensuring you don't accidentally click "Install" before reviewing what else is attempting to get on to your PC. Unchecky isn't 100 percent infallible, but it's a useful extra layer of protection all the same.

Bloatware often makes a return on many PCs when you reinstall using the manufacturer's recovery image. If you've just spent ages meticulously removing this from your system, now's the time to create your own customized recovery image, so when you next reinstall Windows, you don't get all that unwanted software back. Once you've set up your PC as you want it, press Win-X to open the Quick Access menu, then select "Control Panel." When it opens, click "Save backup copies of your files with File History," and choose "System Image Backup" to create a complete image of your hard drive. You can restore this via a Windows recovery drive, or via the Advanced Start-up menu (hold Shift as you click "Start → Power → Restart" to access it).

switch it off, and reclaim that space: Press Win-X to open the Quick Access menu, choose "Command Prompt (Admin)," then type "powercfg.exe /hibernate off" into the command prompt.

Clean out the context menu

One area that can get particularly cluttered is the menus that appear when you right-click items in File Explorer, with programs adding shortcuts of their own. One way to manage these is to manually identify unwanted items when you right-click a particular file or folder, then explore the offending program's own settings for an option to remove the unwanted options.

If you want to remove multiple items in one go, you can either open Registry Editor and browse to "HKEY_CLASSES_ROOT," where you'll need to navigate five different subkeys to find all the offending items, or you can save time by firing up CCleaner, and navigating to "Tools → Startup → Context Menu" for a complete list of options based on directory, drive, and file context menus. Select multiple items using Ctrl-click, then choose "Disable" to temporarily remove them, or "Delete" to get rid permanently.

One often-overlooked area for cleaning is your web browser. How many add-ons are installed? Internet Explorer encourages you to examine and manage these when it detects those that significantly affect

Registry cleaners don't improve performance, and usually introduce more problems than they solve.

startup times, but you can see which plugins and add-ons are installed via your browser's own add-ons screen—how you get here varies from program to program, but Firefox users should type "about:addons" into the Address Bar, while IE users should go to "Tools → Manage Add-ons." If you have multiple browsers, you can also manage these add-ons collectively via CCleaner's "Tools → Browser Plugins" section, where you'll find IE, Firefox, Chrome, and Opera are covered via separate tabs.

Optimize searches

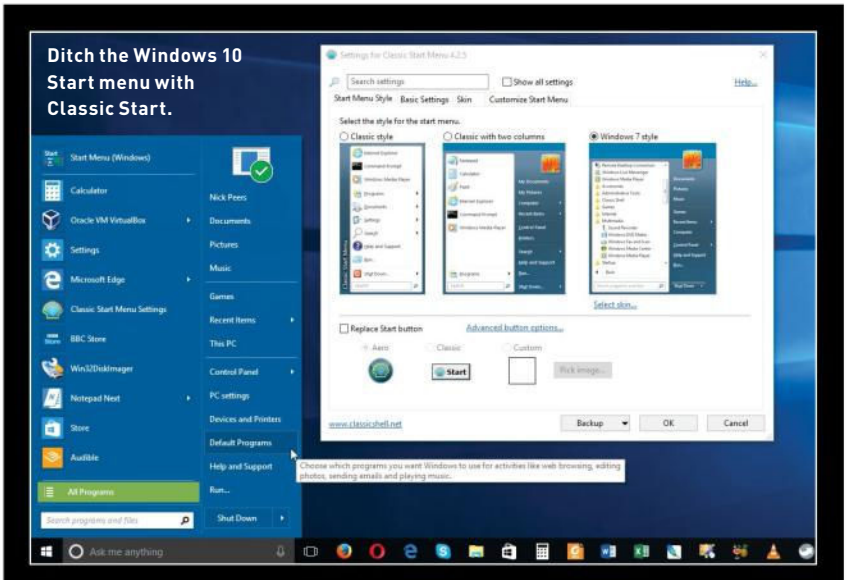
Is Cortana getting on your nerves? Want to limit her influence, or hide her away completely? If the Search box on the Taskbar is distracting, right-click the Taskbar, and choose "Search → Show Search Icon," to replace it with a clickable magnifying glass, or "Hidden" to hide it completely (if you've set up Cortana to respond to voice commands, you can still invoke her using the "Hey Cortana" command).

Hiding Cortana is one thing, removing her requires more work: Click the Search box, then the Notebook icon, and choose "Settings." Flick the top switch to "Off" to disable Cortana. You can restrict the Search box to locally stored results (programs, apps, and files) by flicking "Search online and use web results" to "Off," too. Annoyingly, it's still a two-step process to access the results for personal files—type your terms, then click "Search my stuff."

You can optimize Search in other ways, too: type "search" into the Search box, and click "Change how Windows searches." You'll see which folders have been selected for indexing—click "Modify" to remove unwanted folders (and reduce wear and tear on the drive) by unticking them, plus add others that aren't already in indexed locations, to speed up future searches. Click "Advanced" to perform other related tasks—move the index to another drive, for example, or switch to the "File types" tab to determine which files you want to index, and whether to include the contents (such as text), as well as the properties in the index.

Streamline PC usage

It's not just about making your PC more efficient, you can also speed things up by streamlining the way you use your PC. Get into the habit of using keyboard shortcuts to launch favorite apps, for example—you can manually add these by right-clicking a program's shortcut in File Explorer, and choosing "Properties." Use Alt-Ctrl combinations, or experiment with function keys. You can also quickly launch programs you've pinned to the Taskbar using the Win key plus a number, which launches apps in the order they appear from left to right—



Restore Classic Windows Features

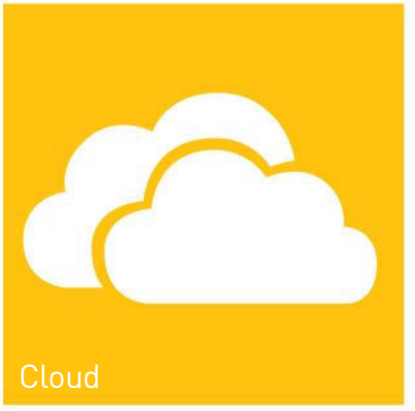
Fed up with certain aspects of Windows 10? Take the Photos app, for instance—if you're wedded to Windows Photo Viewer, you can restore it as the default viewer for your images. If you've just upgraded to Windows 10, head to "Start → Settings → System → Default apps" to select it. Reinstalled from scratch? It's missing, but you can get it back, and the simplest way is through the portable—and completely free—Ultimate Windows Tweaker tool from http://bit.ly/uwt-win10. Once extracted, launch the tool, and head to the "Additional" section, where clicking "Enable Windows Photo Viewer" brings it back, and enables you to set it as default.

Now go to "Customization → Windows 10." You'll find three tweaks that enable you to bring back the old-style battery, date and time, and volume control flyouts in the Taskbar's Notification area—untick the options, and click "Apply."

Can't stand the new Start menu (particularly with its habit of showcasing ads in the form of promoted apps)? You can replace it with a more classically themed menu—either Classic Start (www.classicshell.net) or Start10 ($5, www.stardock.com) will give you a more traditional menu to work with. Classic Shell also comes with a Classic Explorer component, for those who prefer Windows Explorer as it once was.

Unhappy with Settings? The Control Panel is still available, but it's not as easily accessible as it once was. Place it front and center by typing "control panel" into the Search bar, then right-clicking it, and choosing either "Pin to Start" or "Pin to Taskbar."

And speaking of the Control Panel, if you don't like the new Settings Personalization dialog, create a shortcut to the classic Control Panel way of doing things: Right-click inside a folder or on the desktop, and choose "New → Shortcut," then point it to "control.exe desk.cpl,Settings,@Settings." Job done!



one to zero (only the first 10 are registered in this way).

Also look at customizing the Start menu and Quick Access menu (the one that appears when you right-click the Start button, or press Win-X). See "Start → Settings → Personalization → Start" for the former, and download the portable Win+X Menu Editor tool from http://winaero.com/download.php?view.21 to choose exactly which shortcuts to place on the latter.

If your PC is in a secure location and you are its only user, you can save a bit of time when starting Windows by bypassing the lock and logon screens. Type "netplwiz" into the Search box, and click the entry to access the hidden User Accounts Control Panel. Verify your account is selected, then untick "Users must enter a username and password to use this computer." Click "Apply," enter your user password when prompted, and click "OK" twice. When you next reboot, there's no password prompt.

Partition your hard drive

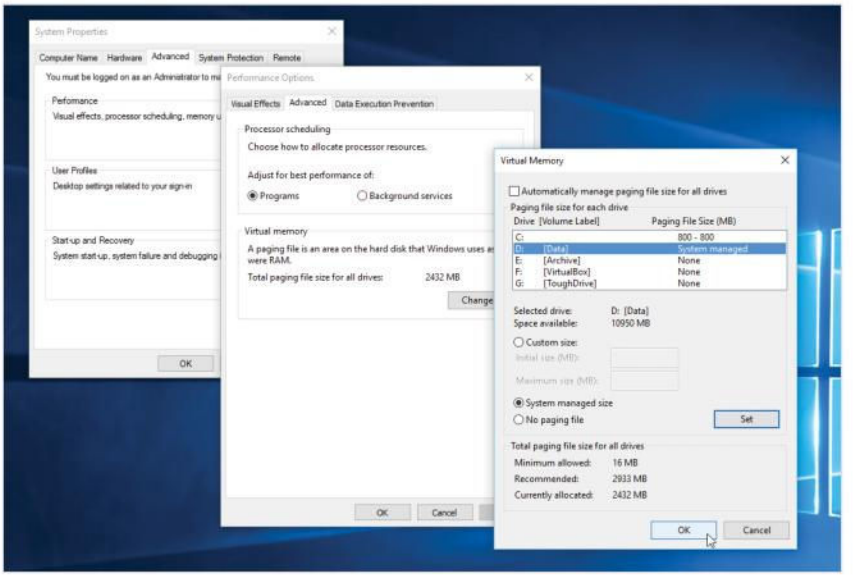
Does your data reside on the same drive as Windows and your programs? That's potentially bad news if Windows suddenly stops working and you're forced to reinstall from scratch. If you keep your data on a separate drive, problems with Windows and programs won't affect it, allowing you the security of troubleshooting and even reinstalling from scratch, or recovering a drive image without touching any of your precious files.

Ideally, your data will reside on a physically separate drive from Windows itself, but this isn't always practical. Instead, investigate partitioning your hard drive, so you create two or more virtual drives in the space usually reserved for one. The tools you need can be found in Windows itself, but make sure you have enough free space on the drive to create a partition large enough to fit all your data files in. To get an idea of how much space you'll need, browse to C:\Users, right-click your username, and choose "Properties."

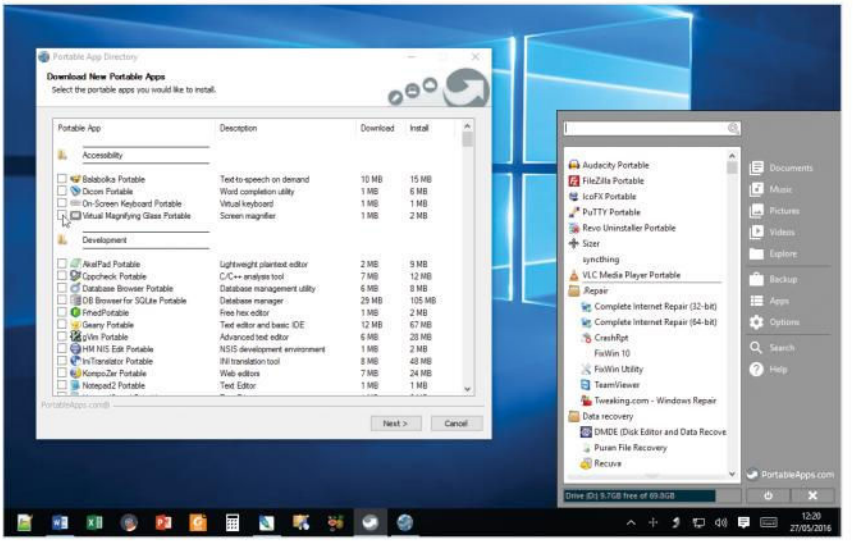
Now click "Start," followed by the "→" button next to File Explorer. Choose "More → Manage" to open the Computer Management Console. Select "Disk Management" under "Storage" to see a graphical view of your hard drive. Adjust the view at the top to reveal how much free space is left on the drive. If there's enough, you can proceed to the next step; if not, you'll need to temporarily move your data from your user folder to another drive, then—once you've verified it's safely transferred—delete the contents of your user folders (but not the parent folders, such as Documents or Pictures) on drive C to free up space.

Next, right-click drive C in the list, and choose "Shrink Volume." You'll see how much space is available to free up—if it doesn't tally with your findings, you'll need to employ a third-party partitioning tool instead; try Minitool Partition Wizard (www.partitionwizard.com), for instance. If there is space, leave at least 10GB (roughly 10,000MB) free, and click "Shrink." Once done, you'll see empty space resides next to your system partition. Right-click this, and choose "New Simple Volume." Follow the prompts to set up a full-sized partition, formatted using NTFS.

Once complete, you'll have a new drive to transfer your files to. To do this properly, so Windows knows where to find your user folders going forward, browse to "C:\Users\<Username>," then right-click each key folder—Documents, Downloads, Videos, and so on—in turn, choose the "Properties → Location" tab, then click "Move." Browse to a suitable location on your newly created



Tweak virtual memory settings for better responsiveness.



Portable apps can survive a Windows reinstall.

partition (create a folder if necessary), and click "Select Folder," choosing "Yes" when prompted to move your data across. If your data has already been moved to the drive, simply move it into the corresponding folders you've just created, and the job is done.

Build a portable toolkit

We love portable apps here at *Maximum PC*. They're confined to a single folder, don't clutter up your system, and—by storing them on your newly created data partition—survive a Windows reinstall, saving you the bother of reinstalling and setting them up again. Store that folder in the cloud or on a USB flash drive, and you can use them on all your machines, too.

An increasing number of programs—mainly system tools, like some of those we've featured, but also full-blown apps, such as LibreOffice, and even your web browser—now come in portable format. If this appeals to you, we recommend going to www.portableapps.com, where you'll find a handy platform that provides you with its own pop-up menu of easily manageable shortcuts, as well as update notifications for apps you install through the platform itself. And you can create your own shortcuts, too, enabling you to place them on your Taskbar or Start menu, for even easier access.

Hardware tweaks

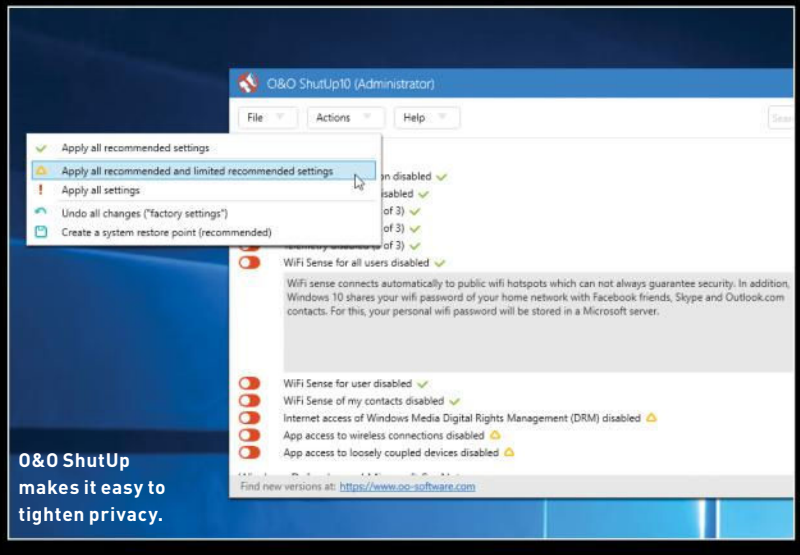
If you really want to lick Windows into shape, it's time to consider replacing that tired mechanical hard drive with a super-fast SSD drive. In fact, if you're upgrading your desktop, purchase a smaller SSD (say 128GB or 256GB) purely for Windows and your programs, then leave your data alone on your existing drive, keeping both physically separate.

Once your drive is fitted, and you're enjoying the sensation of Windows and programs loading in a fraction of the time they used to, why not check to make sure your drive is performing at its very best? Press Win-X, select "Device Manager" from the menu to open Device Manager, then expand "IDE ATA/ATAPI controllers," and verify your system has an AHCI controller instead. Now expand "Disk Drives," and double-click your SSD drive entry. Switch to the "Policies" tab to also verify that write caching is enabled (leave the "Write-cache buffer flushing" setting unticked).

With the basics checked, type "defragment" into the Search bar, and select "Defragment and Optimize your drives." Verify your drive has been correctly identified as a "Solid state drive," so it's optimized correctly (defragging SSDs is a very bad idea).

Next, visit your drive manufacturer's website, and see whether there are any drive utilities that exist that can tweak performance further—people with lots of RAM and Samsung drives should install Samsung Magician, for example, because it offers a RAPID Mode setting, which could speed up read/write times by utilizing spare RAM, although most people have reported that it has most effect on older, slower SATA-II interfaces.

You can speed up the performance of other drives, too—particularly USB ones. Return to Device Manager, and investigate the drive's Policies tab. Here you'll see the drive is optimized for quick removal, but


O&O ShutUp10 (Administrator)
File
Actions
Help
Apply all recommended settings
Apply all recommended and limited recommended settings
Apply all settings
Undo all changes ("factory settings")
Create a system restore point (recommended)
WiFi Sense for all users disabled
WiFi sense connects automatically to public wifi hotspots which can not always guarantee security. In addition, Windows 10 shares your wifi password of your home network with Facebook friends, Skype and Outlook.com contacts. For this, your personal wifi password will be stored in a Microsoft server.
WiFi Sense for user disabled
WiFi Sense of my contacts disabled
Internet access of Windows Media Digital Rights Management (DRM) disabled
App access to wireless connections disabled
App access to loosely coupled devices disabled
Find new versions at: https://www.oo-software.com
O&O ShutUp makes it easy to tighten privacy.

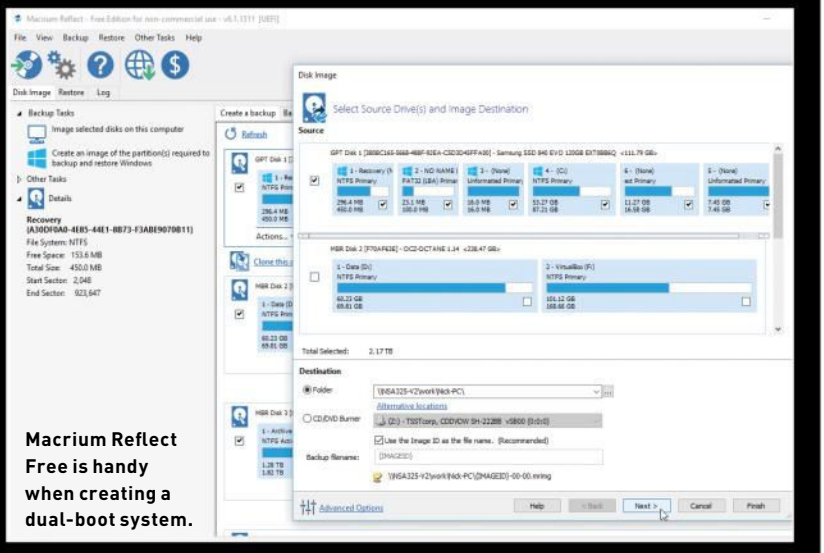
Deal with Privacy Issues

Windows 10 does not have a great reputation for respecting or protecting your privacy. While it's not quite the colander some would have you believe, the operating system definitely needs tightening up. So what can you do about it? If you're about to install or upgrade to Windows 10, make sure you don't choose "Express settings" during setup—you can then review exactly how Windows wants to track your behavior, and decide whether or not to allow it.

It's never too late to tighten privacy, even if you missed this step. Start by going to "Start → Settings → Privacy," and work through the available options. You can configure options such as which apps have access to your camera on an app-by-app basis, or choose a universal setting. If you don't like Cortana, be sure to select "Speech, inking & typing," and click "Stop getting to know me."

Once done, return to the main Settings screen. If you have Wi-Fi, select "Network & Internet → WiFi → Manage WiFi settings." Disable both "Connect to suggested open hotspots" and "Connect to networks shared by my contacts" to disable Microsoft's ill-conceived WiFi Sense feature, which will be dropped from the Anniversary Edition.

If all of this is too much effort, or you want help choosing appropriate privacy settings, you should download and run the free (and portable) O&O ShutUp10 tool from www.oo-software.com (look under "Downloads"). It provides a convenient list of all the most common privacy settings, which you can work through as a series of individual switches. Click a setting to get more information about it. Handy symbols indicate which ones are recommended for disabling (green tick and—with additional review—yellow triangle), and clicking the "Actions" button provides some neat shortcuts to applying all the recommended settings in one go.



Macrium Reflect Free is handy when creating a dual-boot system.

Dual-Boot Windows 7 and 10

You've decided to put it off no longer, and are ready to upgrade to Windows 10 before the free offer runs out. But how can you both upgrade and keep your existing Windows 7 or 8.1 setup? This tip is for more seasoned users only. First, follow our advice to clean up your PC, and make sure Windows is fully up to date. Then follow our recommendations to hive off your data from your Windows partition, and shrink it further to leave space for another partition that will contain Windows 10—this needs to be the same size as your original Windows partition. Remember, if Windows' own partitioning tools complain about the placement of certain files on your disk, use Minitool Partition Wizard instead, which isn't as fussy.

Next, download and install Macrium Reflect Free (www.macrium.com/reflectfree.aspx), and use it to image your Windows partition to your backup drive. Also, make sure you create the rescue media—visit www.techradar.com/1319885 for a complete guide to using Macrium.

Now boot back into Windows 7 and upgrade to Windows 10, fully updating it when done, and performing a "clean" install only after the initial upgrade and activation if you require it. Now use Macrium to restore the OS partition (not the entire disk) to the blank space on the drive. This action means your main partition will be pointing at Windows 10, and your old Windows 7 partition now resides in the empty space that you created previously.

Reboot your PC if necessary, and then download and install EasyBCD from https://neosmart.net/EasyBCD/—you can then use this to add Windows 7 to the list of available boot options, giving you your dual-boot setup. If things go wrong, restore your Macrium drive image (this time, restore the entire disk instead of an individual partition), and start again.

if you rarely disconnect it, select "Better performance," having read the warning.

If you have two or more physical drives installed, consider moving your paging file to the non-system drive, to help speed things up—note, if your system drive is SSD, but the other isn't, skip this step. Open "System" via the Quick Access menu, and click "Advanced system settings." Click "Settings" under "Performance," switch to the Advanced tab, and click "Change." Untick the automatic option before selecting drive C. Choose "No paging file," and click "Set," ignoring the warning about Windows not being able to record information in the event of a crash (it'll be stored in the paging file on your other drive). Select your other drive, choose "System managed size," and click "Set" again. Click "OK" three times, and reboot when prompted. Once complete, return to this screen, and verify that drive C has no paging file, and your second drive has a system-managed paging file in place. With the load spread more evenly, you should see further performance improvements.

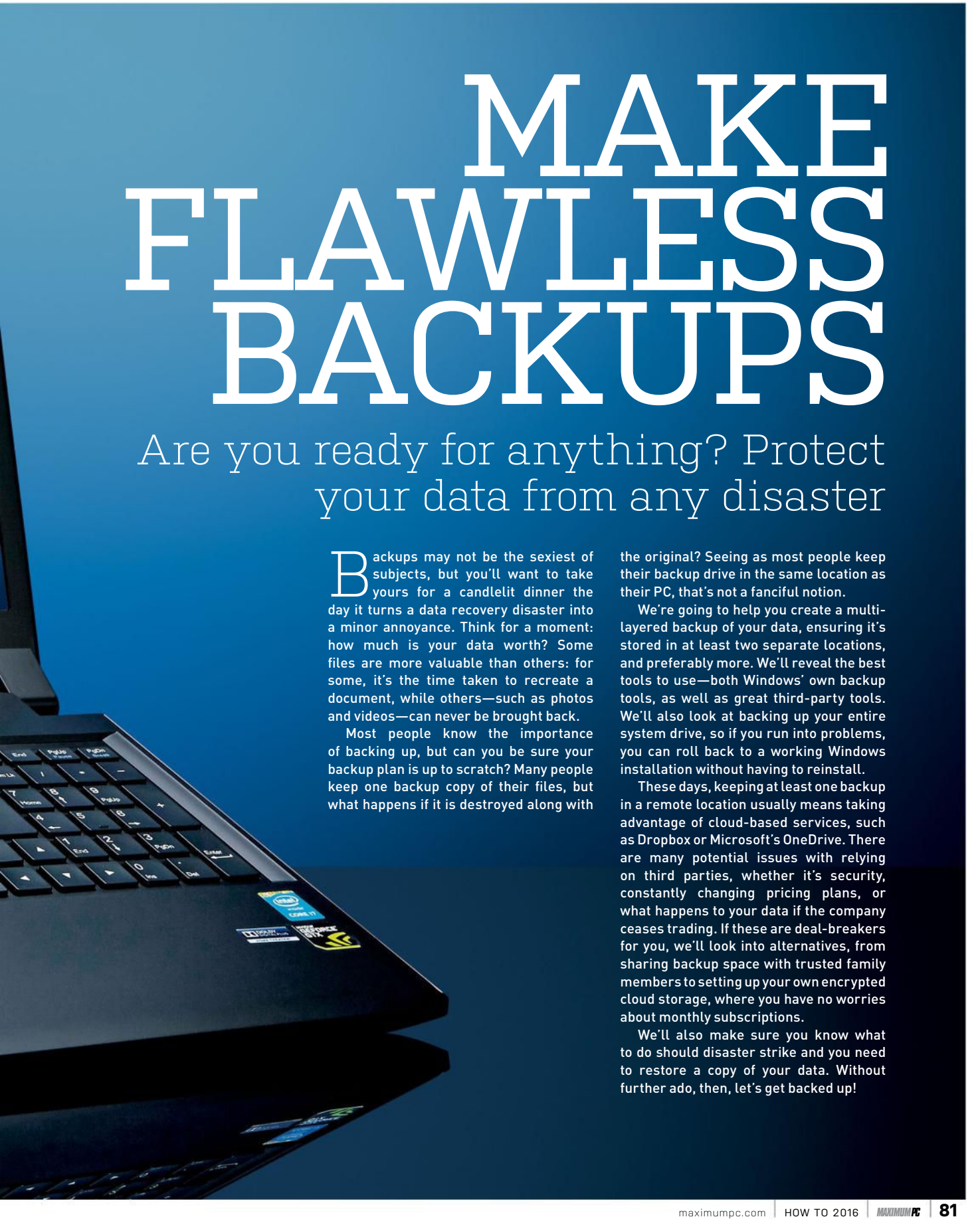
Is your PC as energy efficient as it could be? Get detailed information about your hardware's energy capabilities—plus any known problems—by generating an energy report from an Administrative Command Prompt. Type "cd %userprofile%/desktop" followed by "powercfg -energy." After about 60 seconds, an energy-report.html file is generated on your desktop—double-click it to review its findings in your browser. Visit http://support.microsoft.com/kb/976034 for more information about how to analyze its readings. From here, you can tweak your settings accordingly—both through the Power Options Control Panel, as well as Device Manager (look for a Power Management tab for available options).

Finally, want to clear out Device Manager? When you disconnect devices, they disappear from view, but if you select "View → Show Hidden Devices," they appear in the list. From here, you can right-click the device in question, and choose "Uninstall" to remove its drivers.

Macrium Reflect - Free Edition for non-commercial use - v6.1.1081 [UEFI]
File View Backup Restore Other Tasks Help
Disk Image Restore Log
Backup Tasks
Image selected disks on this computer
Create an image of the partition(s) required to backup and restore Windows
Other Tasks
Create a backup Backup Definition Files Scheduled Backups
File Name Path Type
Backup to Network.xml D:\Nick\Documents\Reflect\
My Backup.xml D:\Nick\Documents\Reflect\
Image Options XML View
Imaging Summary
Retention Rules
Destination:
Select Source Drive(s) and Image Destination
Source
Total Selected: 32.95 GB
Destination
Folder
CD/DVD Burner
Backup filename:
Advanced Options
Backup Locations
Edit the list of alternative backup locations
When a backup is running, each location in this list will be tried in sequence until a valid location is found.
This enables, for example, backup rotations to use multiple external drives that are assigned different drive letters by Windows. Note: During the backup, missing sub-folders will be created automatically.
Type in a folder here to add as an alternative location
Add to list
Reorder priority: Up Down Remove
Folder
\\NSA325-V2\work\Nick-PC\
G:\Macrium\
Help OK Cancel
GIGABYTE
P55

MAKE FLAWLESS BACKUPS

Are you ready for anything? Protect your data from any disaster



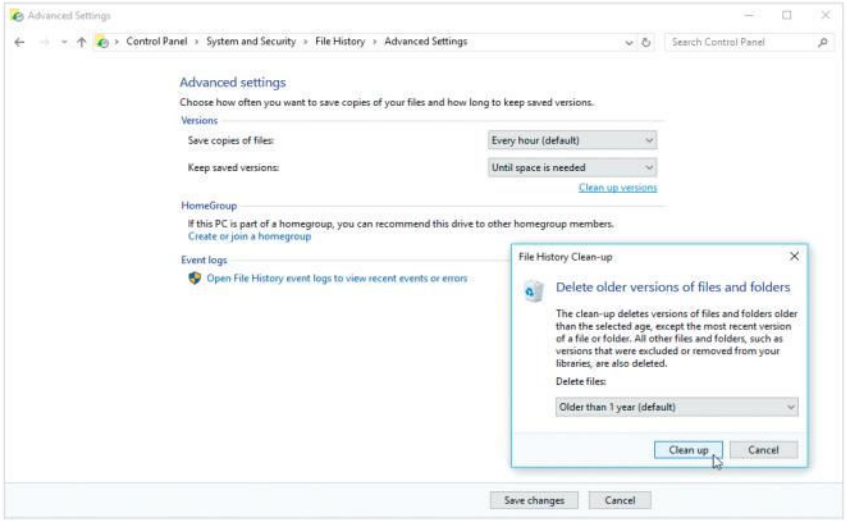
Backups may not be the sexiest of subjects, but you'll want to take yours for a candlelit dinner the day it turns a data recovery disaster into a minor annoyance. Think for a moment: how much is your data worth? Some files are more valuable than others: for some, it's the time taken to recreate a document, while others—such as photos and videos—can never be brought back.

Most people know the importance of backing up, but can you be sure your backup plan is up to scratch? Many people keep one backup copy of their files, but what happens if it is destroyed along with the original? Seeing as most people keep their backup drive in the same location as their PC, that's not a fanciful notion.

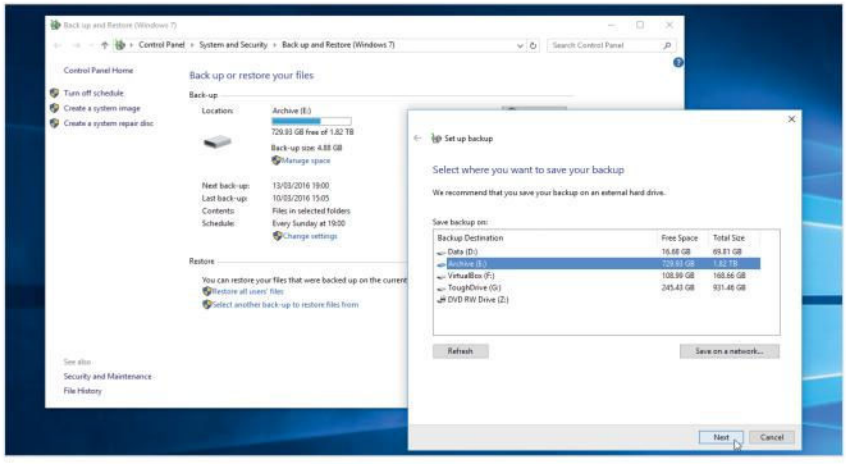
We're going to help you create a multi-layered backup of your data, ensuring it's stored in at least two separate locations, and preferably more. We'll reveal the best tools to use—both Windows' own backup tools, as well as great third-party tools. We'll also look at backing up your entire system drive, so if you run into problems, you can roll back to a working Windows installation without having to reinstall.

These days, keeping at least one backup in a remote location usually means taking advantage of cloud-based services, such as Dropbox or Microsoft's OneDrive. There are many potential issues with relying on third parties, whether it's security, constantly changing pricing plans, or what happens to your data if the company ceases trading. If these are deal-breakers for you, we'll look into alternatives, from sharing backup space with trusted family members to setting up your own encrypted cloud storage, where you have no worries about monthly subscriptions.

We'll also make sure you know what to do should disaster strike and you need to restore a copy of your data. Without further ado, then, let's get backed up!


Advanced Settings
Control Panel › System and Security › File History › Advanced Settings
Search Control Panel
Advanced settings
Choose how often you want to save copies of your files and how long to keep saved versions.
Versions
Save copies of files:
Every hour (default)
Keep saved versions:
Until space is needed
Clean up versions
HomeGroup
If this PC is part of a homegroup, you can recommend this drive to other homegroup members.
Create or join a homegroup
Event logs
Open File History event logs to view recent events or errors
File History Clean-up
Delete older versions of files and folders
The clean-up deletes versions of files and folders older than the selected age, except the most recent version of a file or folder. All other files and folders, such as versions that were excluded or removed from your libraries, are also deleted.
Delete files:
Older than 1 year (default)
Clean up
Cancel
Save changes
Cancel

Make File History your first port of call.



Windows 7's Backup and Restore is available in Windows 10.

Select your backup device

When it comes to choosing where to back up your files to, you're spoiled for choice. But it's not a case of either this backup device or that one— ideally, you should invest in at least two separate devices. Here's what to look for.

Secondary hard drive: this can be internal or external (USB). Use it for your primary file and drive image backups, using Windows' own tools and Macrium Reflect Free.

Network hard drive: a good secondary solution that can be kept elsewhere in your home for added security. Perfect for any of the backup methods we discuss here—you can even use it as the basis for your own personal cloud storage system using OwnCloud.

Other computer: if you own another PC (or Mac), keep your key files in sync on all your computers using a cloud storage service or Syncthing. As an added bonus, the latest version of your data is always available to whichever PC you're using.

Friend's or family computer: you can swap unused storage space with people you trust, but make sure your data is kept in an encrypted format on their computer—use Buddy Backup or Viivo in conjunction with Syncthing.

Cloud storage: if you have a fast, unlimited Internet connection, using a trusted service such as Dropbox, Microsoft OneDrive, or Google Drive is also an option. Again, use Viivo to encrypt sensitive data for extra security.

Synology's DS216+ network drive is a great backup device.

You may already have a basic backup plan in place—Windows 10 makes this easy by offering you a choice of two routes, including both Backup and Restore from Windows 7, and File History from Windows 8. They're easy to access and set up—search the "Start" menu or Cortana for "backup." Both focus on producing backups of key documents, photos, and other personal data, and can back up to any drive that's visible to your PC, including network attached storage.

Rule one of our backup strategy is to make use of multiple backup locations (see "Select your backup device," below-left). Neither File History nor Backup and Restore allow you to back up to alternate locations, but if you're running Windows 10, you can employ both together to get around this restriction. Configure File History to back up to one location—we recommend a drive physically attached to your PC—and use Backup and Restore to back up to another drive, preferably a shared folder on your network drive. File History constantly monitors for changes and backs up as necessary, while you should schedule Backup and Restore to run weekly at a time that won't interfere with your PC use—say, lunchtime on the weekend.

System backups

Your data is taken care of, but what about Windows? If disaster strikes, you could find yourself spending days getting your PC set up again—but if you take a full system backup (known as a "drive image"), you can have your PC up and running again within an hour. Windows offers to create a system image when you set up Backup and Restore, but there are weaknesses. First, each backup requires tens of gigabytes of space on your PC. Second, images aren't verified when they're created, so you've no way of knowing if you can rely on them. And third, images are only stored on a single drive.

Eliminate all three weaknesses by employing the services of our favorite drive-imaging tool, Macrium Reflect. We've used it to back up (and rescue) Windows countless times over the past five years, and nothing comes close to it. Start with the powerful Free version at www.macrium.com/reflectfree.asp, which solves the issue with space by using differential images that take up much less room by only recording the changes made since the last backup was taken.

Launch Macrium Reflect Free once installed, and click

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"Create an image of the partition(s) required to backup and restore Windows." Next, set your destination—a folder on your backup drive. You might want to change the file name to something more easily recognizable, and take the time to click "Advanced Options" to select "Auto Verify Image" to ensure your backup is checked for errors after it's been taken. Once done, pick a backup schedule—we recommended pairing one monthly full backup with weekly differential backups, or choosing the "Differential Backup Set" template for more frequent daily backups. Click "Next" followed by "Finish."

In the spirit of data redundancy, you should then repeat the process, creating a second definition rule pointing toward your secondary backup drive—speed things up by right-clicking the rule you just created and choosing "Duplicate." Don't forget to create the rescue media (DVD or 4GB USB flash drive) when prompted by Macrium—this ensures you'll be able to restore your system even if Windows won't boot.

If you want more features—including incremental backups, and the ability to back up files and folders—upgrade to Macrium Reflect Home Edition for a one-off $69.95.

The power of the cloud

These days, backups are synonymous with the word "cloud," the logic being that storing backups in the cloud ensures one copy of your data is kept off-site in a secure location in case of fire, theft, or worse. It makes sense, although there are some drawbacks (see below). The obvious choice when backing up to the cloud is to employ a known solution—Microsoft's OneDrive service is baked into Windows 10, but alternate trusted sources include Dropbox (www.dropbox.com) and Google Drive (https://drive.google.com).

Each service offers limited free plans of around 5–15GB of free storage space, which is fine for personal files, such as documents, photos, and even some video, but if you run out of space, you'll need to upgrade to a monthly or annual subscription. One of the best value solutions is to install Office 365 for $9.99 a month or $99.99 a year—your subscription includes 1TB of cloud storage as well as access to the latest version of Microsoft Office for up to five users.

However, there are some reasons to treat cloud storage with suspicion. These include ongoing costs, the security of your data, and what happens if the company in question either goes out of business or discontinues its product, as users of Wuala and AVG LiveKive cloud storage services have discovered to their cost over the years.

In terms of fees, consider prioritizing what data you store in the cloud—do you need your videos backed up online, for example? As you have a local backup in place, you could focus on storing important documents and photos in the cloud, where you're unlikely to run out of space quickly. That way, you can usually get away with free storage plans.

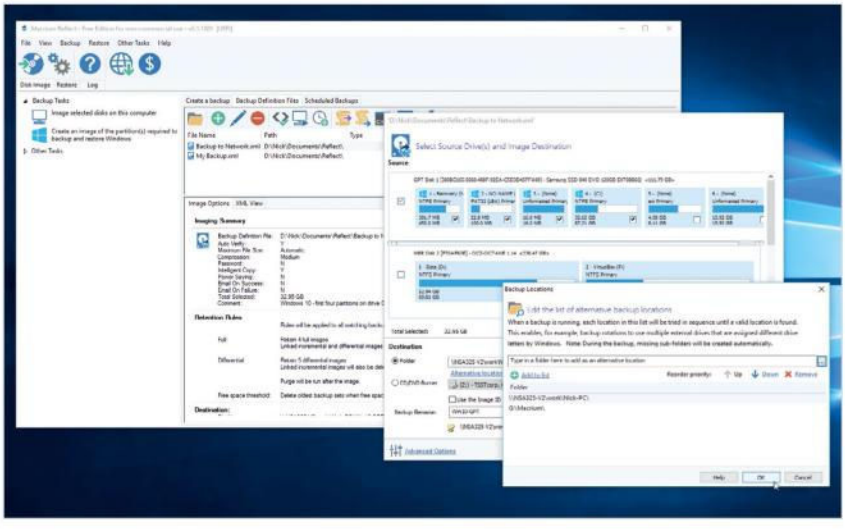
If you don't trust your cloud provider's encryption, add a secondary layer of encryption to sensitive files before uploading them to the cloud. The best tool for this purpose is Viivo (https://viivo.com), which works with multiple cloud providers, and includes tools for sharing access to files with trusted family and friends. It's free for personal use, but make sure you keep a separate, unencrypted backup of this data somewhere safe, too, to ensure you're not locked out of your files for any reason.

Alternate strategies

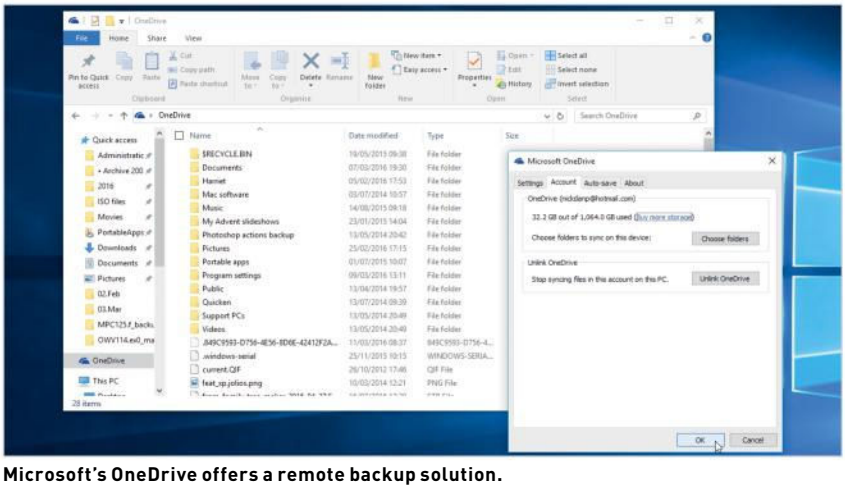
There are two principal alternatives to putting your data in the hands of a third-party provider. Both can be used over the Internet if you have a fast and unmetered connection, but you can also use them exclusively over your local network, too, ensuring your data never touches the cloud in any shape or form.

The first of these options involves synching data from selected folders directly between two or more computers. It works beautifully over your local network, as well as the wider Internet, if necessary. It's perfect for keeping files in sync between computers you own, and creates an exact copy of your files, so there are no issues with proprietary file formats. Naturally, the connection is encrypted, and the software is open source.

The program in question is called Syncthing, and it works across Windows, Linux, and Mac, and can even be directly installed to selected network drives. We recommend installing the GTK build from https://github.com/syncthing/syncthing-gtk—install it on both computers, then select the folder you wish to sync on your main computer, before connecting it and your other PC together. Once done, the files are kept in sync automatically whenever



We've trusted Macrium for over five years.



Microsoft's OneDrive offers a remote backup solution.

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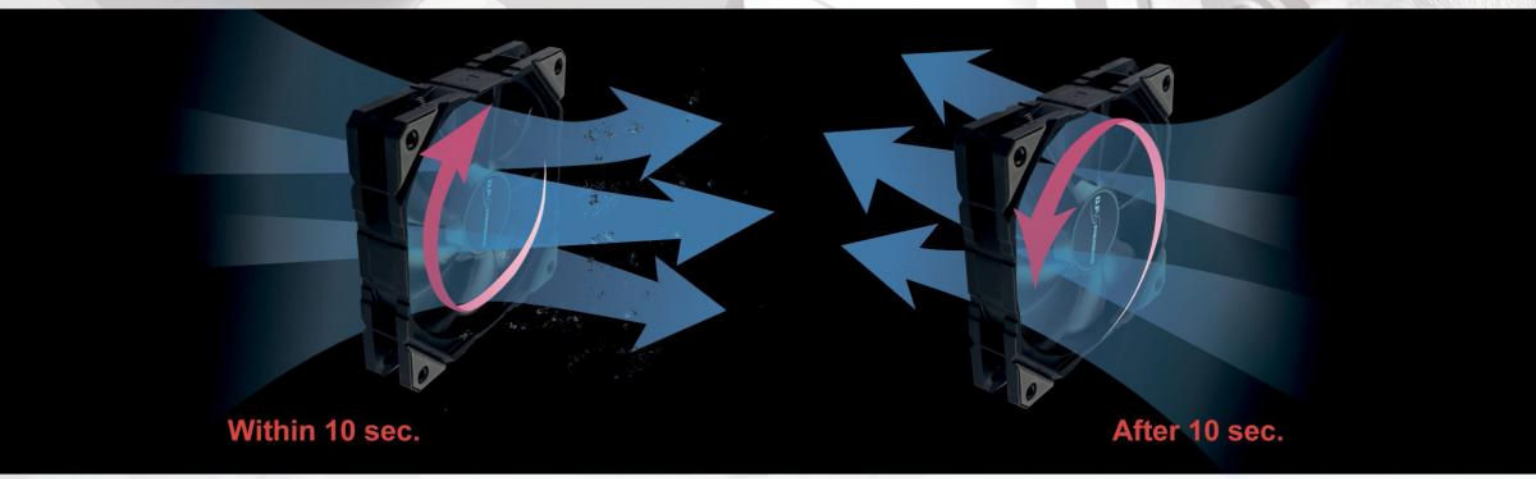

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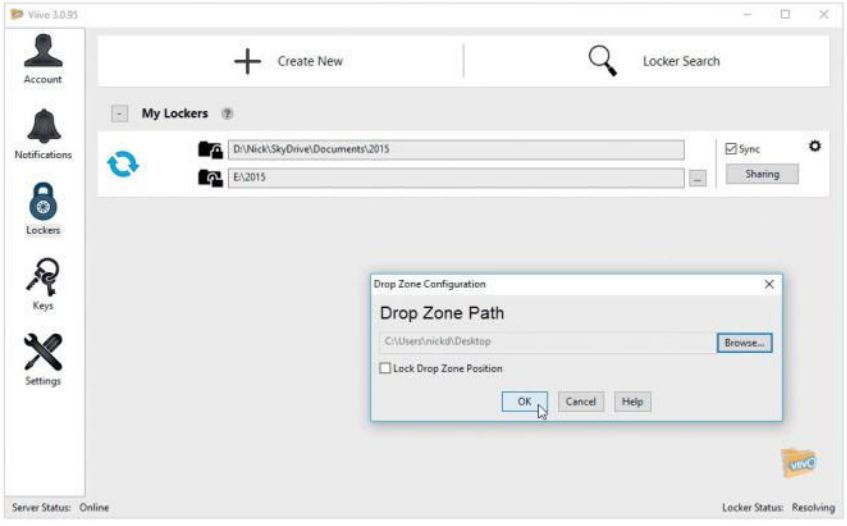
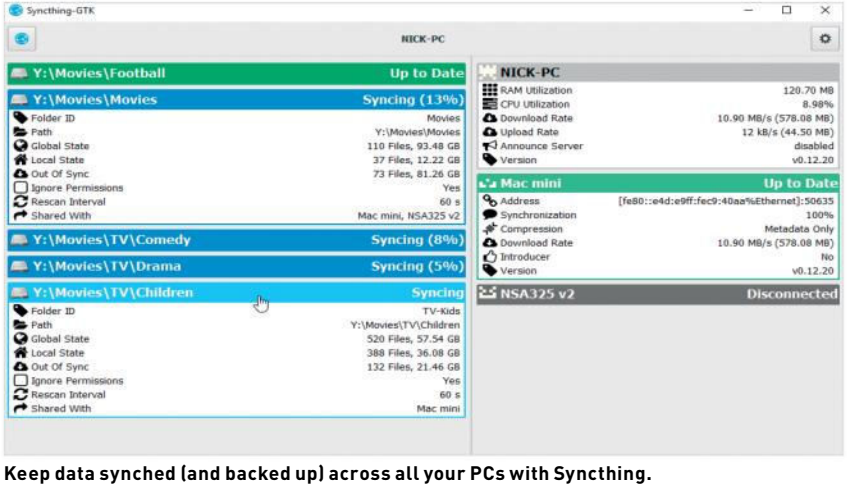


Worried about sensitive data? Viivo adds more encryption.



Keep data synched (and backed up) across all your PCs with Syncthing.

Syncthing runs—configure it to start with Windows, to ensure it's always backing up.

Files are transferred directly between computers, so they both need to be on and connected for files to sync. If you wanted to store backups remotely on friends' and family's PCs, take a look at BuddyBackup (www.buddybackup.com), which encrypts your data so it's unreadable on the computers you back it up to.

Your personal cloud

If you'd like to store files centrally (creating an additional backup of your files in the process), without relying on a third party, then set up your own using a spare PC or network hard drive as the file server.

Some network drives come with their own proprietary cloud systems—My Cloud from Western Digital, for example—but we recommend choosing something open source and more widely supported: OwnCloud (https://owncloud.org), which works across a variety of platforms. The server part can be installed to many network drives—including Zyxel and Synology (the latter via https://synocommunity.com)—as well as Linux-powered PCs, including the Raspberry Pi 2, if you're looking for a low-cost solution. You then download and install the desktop and mobile clients on Windows, Mac, Linux, Android, iOS, and other supported platforms, to allow you to both sync and access your files from anywhere.

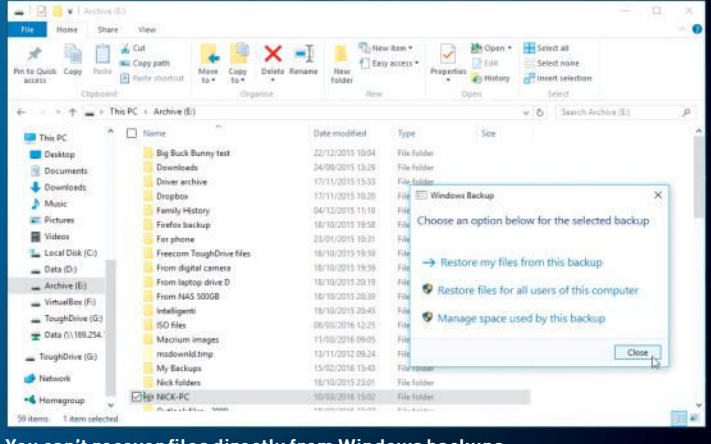
Think of OwnCloud as being your own personal cloud storage system—you're not tied to any third parties, there are no monthly fees to pay for storage, and your cloud can be restricted to your local network

Protect your backups

Nothing lasts forever—and the same is true of backups. Optical discs don't last a lifetime, as we once thought, while hard drives physically wear out, and cloud storage can disappear without warning. That's why backing up to multiple locations is essential, but it doesn't stop there. You should take additional steps to protect your data from physical degradation.

Check with the maker of your drive for a monitoring tool, such as Seagate's SeaTools (www.seagate.com/seatools), to keep an eye on your drives' health, giving you time to replace failing drives before they disappear with your data. If you want a network drive, choose a two-bay model, such as Synology's DiskStation 216+, and fill it with two identical drives in a RAID 1 setup. Data is mirrored on both drives, so if one fails, you can swap it out with a replacement without fear of data loss. Just remember a RAID array doesn't constitute two backups—if the enclosure fries (or gets stolen), you lose both drives. (As an aside, try the free DMDE data recovery tool from www.dmde.com if you need to recover data from NAS-formatted drives.)

Also watch the software you use. Some tools store your data in their own proprietary formats, so if the software stops working (perhaps after upgrading to an unsupported version of Windows), you lose access to your backup. Both Windows backup tools use their own format, as does Macrium, Backup Buddy, and Viivo (as part of protecting backups through encryption). So, make sure one of your backup plans simply duplicates your files in their original format to ensure you have one easily recoverable version of your files—Syncthing, OwnCloud, and other cloud storage providers all do this.


Windows Backup
Choose an option below for the selected backup
Restore my files from this backup
Restore files for all users of this computer
Manage space used by this backup
Close

You can't recover files directly from Windows backups.

or opened up securely for access over the Internet, should you need it. It works with multiple users, too, so everyone in your household gets their own secure storage space (with quotas to limit individuals from hogging the drive for their own files).

Some initial configuration is required, but everything's point-and-click, with a useful manual on hand to steer you in the right direction. One tip: When asked to set up your initial account, be sure to click "Storage & database" to select the MySQL option, rather than the default SQLite one. This will dramatically speed up the server's performance when it comes to synching large batches of files.

Restoring from backups

Disaster has struck—you've lost data for one reason or another, so what next? Thanks to your backup plan, you should find you're able to quickly and relatively painlessly restore the data you lost. If you've used File History, navigate to the folder with the missing data in File Explorer, and click the "History" button on the "File" tab.

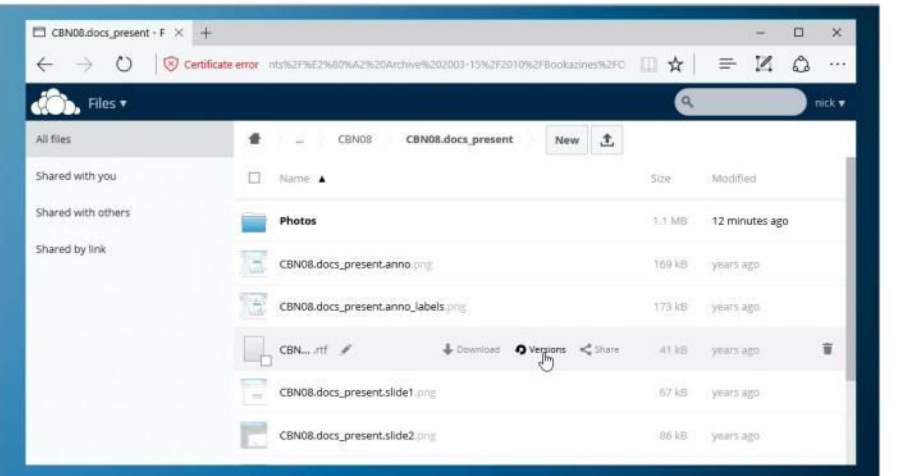
A window opens displaying all the backed-up files in that folder—double-click the missing file to preview it, then click the "Settings" button and choose "Restore" to save it to the current location, or "Restore to" to save it elsewhere. If you're trying to recover an earlier version of a file, use the left and right buttons at the bottom of the page to navigate between available versions, until you find what you need.

If you're recovering from Backup and Restore, browse to the drive or folder containing your backup, then double-click it and choose "Restore my files from this backup." Click "Choose a different date" if you're looking for older versions of your files, or use the search and browse buttons to locate what you want to restore. You can restore them to their original location, or choose another—make sure you leave "Restore the files to their original subfolders" ticked to preserve the original folder structure, before clicking "Restore."

Need to recover your entire PC? Macrium Reflect makes things straightforward: If you can boot into Windows, launch the app and switch to the "Restore" tab; otherwise, boot from your rescue media. Either select the backup you want to roll back to from the list given, or click "Browse for an image file" to locate it manually. Select "Restore Image" to restore the full image, or choose "Browse Image" to mount the image as a virtual drive, enabling you to browse it as a virtual drive in Windows itself—a good option for recovering individual files and folders from the backup. Make sure you tick "Enable access to restricted folders" to allow you to recover data from user folders and other protected places.

Restoring files from the cloud isn't usually an issue, because everything's kept in sync, but if you need to restore a file you've accidentally deleted, then taking OneDrive as an example, log into your OneDrive account through your browser. Click the ≡ button and select "Recycle bin" under your PC's entry to see if it's still recoverable.

Recovering data from OwnCloud is simple, too—when you reinstall the software and log in as your own user, you're prompted to choose which folder on your hard drive to store your OneDrive content on—once done, the folder syncs up with what's online, restoring any missing data, or you can log on through your browser to download individual files if necessary.



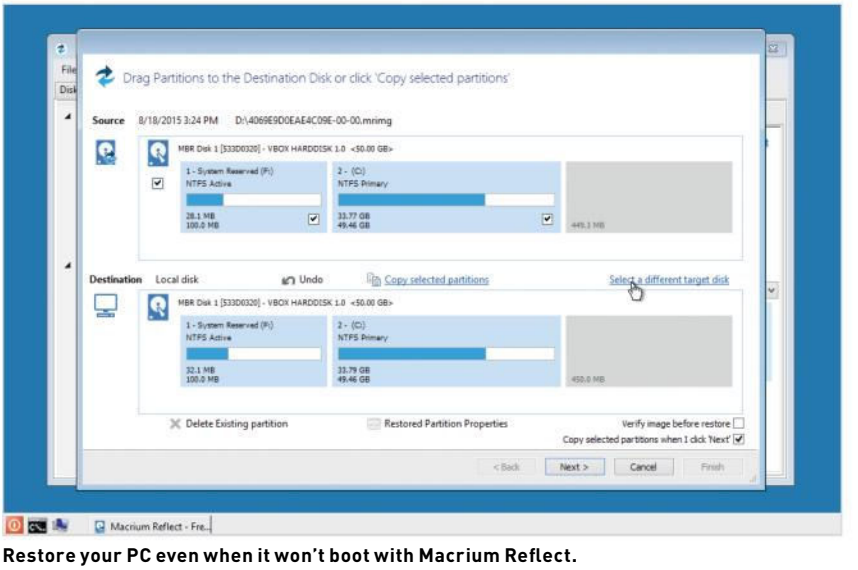
Back up file revisions

One of the fringe benefits of following our backup plan is that many of the tools on offer record multiple versions of your files, enabling you to undo changes to files as well as restore lost, deleted, or corrupt data. Both Windows backup tools support this, although File History's default settings of updating your files every hour (rather than weekly, as with the Backup and Restore tool) means you have greater flexibility.

If you back up files to OneDrive, Dropbox, or your own OwnCloud server, access your account through your web browser, then locate the file in question. OwnCloud users should click the "Versions" option next to the filename; otherwise, right-click the file and choose the option to restore a previous version, to see what's available based on time and date. You can often preview earlier revisions by clicking them.

Syncthing only stores one revision of a file by default, but you can change this on a folder-by-folder basis. Right-click the folder bar in Syncthing-GTK, and choose "Edit," then select an option from the "File Versioning" menu—each has a description, and you get context-sensitive options, such as the number of versions to keep.

One caveat: storing multiple versions of files requires more space than straight one-to-one backups. Bear this in mind when choosing what size hard drive to buy.



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A CASE AND FANS
All respectable cases have support for fan mounts internally.

INTERNAL AIRFLOW; let's cut the crap—it's one of the biggest dividers of opinion there is, second only to cake or pie. So, why is it so complex? What's a positive or negative pressure system? Static pressure? CFM? What's that? Well, that's what we're here to answer. Whether your woes lie with choosing which fans to use to cool your mighty AIO, or with the age-old argument between static pressure and high airflow fans, don't you worry—we've got your back!

Is internal airflow really that important? In a lot of ways, it's more vital than people realize; the more air you circulate, the better temperatures you'll have internally, and the more comfortable your overclocks will remain in turn. Also, you can wow everyone with your in-depth knowledge of fans. Come on—who doesn't love fan tips? **–ZAK STOREY**

1 FAN ORIENTATION

The first thing you need to identify when it comes to your fans is which way pulls air in, and which pushes it out. Most commonly, the side with the blades exposed is the intake, and the side with the guards will exhaust air around or out of your chassis.

2 STATIC PRESSURE VERSUS AIRFLOW

Identifying a static pressure optimized fan as opposed to an airflow fan is crucial. An easy way to tell them apart is the design and orientation of the fan blades. Fat and wide [**Image A**]? You're looking at a static pressure fan. Skinny and sleek? That's airflow optimized. Static pressure is designed to force air through dense or resistive areas, while airflow fans push larger quantities of air into a chassis at a lower pressure.

3 WHEN TO USE A STATIC PRESSURE FAN

We'll no doubt divide opinion here. Static pressure fans are absolutely fantastic for radiators, AIO coolers, and CPU heatsinks. Usually, those pesky air towers and radiators have a compact enough arrangement that a static pressure fan can easily take advantage of the higher pressure. However, this isn't always the case. For radiators, in particular, it can depend on the density of the fins within it, also known as FPI (fins per inch). In short, the higher the density, the higher the static pressure you'll need to push cool air through it. Take EKWB's XE 240mm radiator. It's a thick old girl—coming in at just under 2.4 inches in depth, it

features an FPI of just 16 [**Image B**]. However, if you take the PE variant, coming in at a meager 1.5 inches, you'll notice it has an FPI of 38. In this scenario, you would be far better off using a static pressure fan. However, the first radiator really wouldn't see any gains from using one, because the density is just too low.

4 WHEN TO USE AN AIRFLOW FAN

This is a little easier to answer now we've clarified the radiator conundrum. In short, if you've got absolutely no resistance, unless you're trying to thematically match a build with all the same fans, you should always choose an airflow optimized fan. It's not as difficult as it sounds—most companies offer both static pressure optimized and a standard airflow variant of the same fan design; Corsair's AF120 and SP120 series, for example. Of course, if your radiator has less than 18 FPI, you'll actually save yourself a few bucks by grabbing that airflow fan instead of the SP variant, because you won't see any performance benefits with an SP fan.

5 WHAT'S ALL THIS ABOUT RPM?

RPM, or revolutions per minute, applies here exactly as it would in a combustion engine. The higher the revolutions, the higher the performance, but that comes at a price. Noctua's NF-F12 IPPC fans are a good example. They come in two variants (three if you include the IP67 version): a 3,000rpm version, and a 2,000rpm version. Now, the 3,000 variant pushes 109.8 CFM (cubic feet per minute)

C

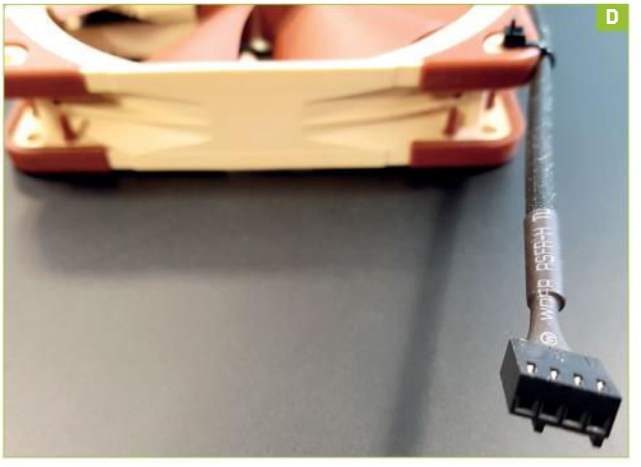
for airflow, and has a phenomenal static pressure of 7.63mm H_2O. However, at full whack, you also get a very noisy 43.5dB(A), which is bad. Compare that with the 2,000rpm variant, and you're down to 71.7 CFM on airflow, and a static pressure rating of 3.94mm H_2O. The advantage? You'll be greeted by 29.7dB(A) instead, which is around the same as a stock Corsair fan found in the H100i.

6 HOW CAN YOU REDUCE NOISE LEVELS?

Short of buying slower fans (1,500rpm or below), you can use low-noise adapters to reduce the voltage powering the fan, or use PWM variants instead, so you can control the fan speeds with pinprick precision through fan control software on your desktop. You could also install fans with rubber grommets [**Image C**], as opposed to the traditional fan screw. Outside of fans, you could opt for a noise-optimized case—one that uses sound-dampening material, such as Fractal's Define R5. Although the side panels will inherently be heavier, due to the noise-dampening fabric attached to the interior panels, it will deaden any excessive vibrations dramatically. Failing that, you could opt to use a fan controller, such as Phantek's PWM fan hub. These work similarly to a low-noise adapter, and most enable you to plug both PWM and 3-pin fan headers directly into them, which are then controlled by a single header, or software on the motherboard itself.

7 WHAT DO ALL THOSE NUMBERS MEAN?

To get a good idea of what these figures represent, your best bet is to compare several different fans on your favorite etailer's website. But for a quick roundup, static pressure is often measured in mm H_2O (2.2 is the average), higher equals better. Airflow is measured in CFM (70–80 is the average), higher is still better. Noise levels are measured in dB(A), 16 being super-quiet, 30 being your average CPU cooler fan at full load, 40 being a localized


D

E

earthquake within your chassis (OK, we jest here, but you get the point).

8 PULSE WIDTH MODULATION (PWM)

PWM fans account for about 30 percent of the total fans out there today. In short, instead of utilizing 12V, 7V, or 5V to power the fans, the additional pin [**Image D**] allows the motherboard to fluctuate the amount of voltage powering the fan. This way, it can control the fan's speed with incredible accuracy.

9 WHAT'S NEGATIVE AND POSITIVE PRESSURE?

These phrases refer to how you have your case set up. It sounds ridiculous, but once you introduce fans to a system, you actually create a pressure system inside the closed chassis. There are three different types of pressure system: a balanced system, where there's just as much air going in as going out (two intakes, two exhausts); a negative pressure system, where more air is being exhausted than is being brought into the chassis (one intake, three exhausts); and a positive pressure system, where more air is being brought into the chassis than exhausted (three intakes, one exhaust). In reality, they are all equally effective at cooling, and you'll only find very minor differences between the three. After all, exhausting hot air out of your chassis helps keep your motherboard on ice and your overclocks steady, and replacing that hot air with cold air through an intake helps as well. Ultimately, it's all about air circulation, far more than whether you run a positive, negative, or balanced system.

10 BALANCE IS KEY, THEN?

Well, no—it's actually more about dust than anything else. In today's world, cases are littered with dust filters: intakes designed to reduce the amount of dust entering your system. After all, dust is the biggest hardware killer of them all, and for an aesthetic build, it looks awful as well. But even with all of those filters, you're still going to have holes and areas that aren't filtered (rear exhaust slots, PCIe slots, and other gaps in the case's construction). In a negative system, thanks to thermodynamics, cool air is pulled in through all of these unfiltered areas, in turn bringing dust into the system. However, in a positive system [**Image E**], air is actually exhausted or pushed out of these gaps and unfiltered areas, pushing the dust out of your case as well. It's not going to keep the dust out indefinitely, but it'll certainly help, and it means your system will require a lot less maintenance overall.

Stream Your Gaming With XSplit

YOU'LL NEED THIS

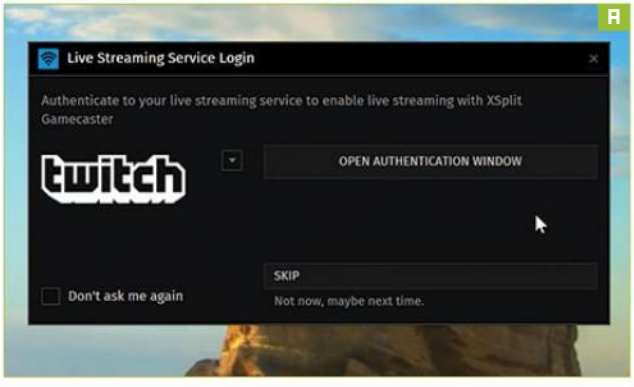
A TWITCH ACCOUNT
Register at www.twitch.tv.

XSPLIT GAMECASTER
Download from www.xsplit.com.

HEADSET, WEBCAM, PC, AND ONLINE CONNECTION
This takes a lot of CPU power.

GAME STREAMING IS A SERIOUS BUSINESS. For some people, it's actually possible (though improbable) to make a living sitting in front of your PC, thanks to the generosity of viewers, and Twitch's numerous partnership schemes. We're not here today to teach you those particular secrets, though. We're working on the most important step: getting yourself out there in a presentable, watchable manner.

It's worth mentioning here that this tutorial doesn't only work for Twitch, though that's the service most people use—you can also use XSplit Gamecaster to send your various embarrassing misplays and goofups to Hitbox, YouTube Live, and a number of other services. We'll show you how to add additional accounts. And we're working with the basic version of XSplit here; picking up a license (from $2.50 per month) will add heaps of extra features, and enable 1080p streaming without a watermark, so it's worth considering if you're picking up streaming steam. –ALEX COX


A
Live Streaming Service Login
Authenticate to your live streaming service to enable live streaming with XSplit Gamecaster
twitch
OPEN AUTHENTICATION WINDOW
SKIP
Don't ask me again
Not now, maybe next time.

1 DOWNLOAD AND INSTALL

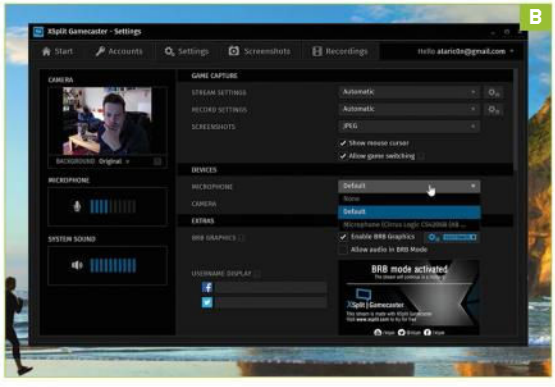
We'll begin with the obvious setup steps, and not go into huge detail because, hey, you can handle it, champ. Register a Twitch account at www.twitch.tv, register an XSplit account at www.xsplit.com, then follow the links in your email to activate these accounts. Download XSplit Gamecaster and install it—if your machine is missing any of the prerequisites it needs, it grabs them and installs them for you, so make sure you're online while you install. Run Gamecaster for the first time, and you're given the option to connect to your streaming service [Image A]. Twitch is selected by default, so click "Open Authentication Window," log in, and click the "Authorize" button to share the relevant security keys from your account with XSplit.

2 YOUR FIRST STREAM

Once Gamecaster has fully run, you're already set to pull off a basic stream—simply open your chosen game, hit Ctrl-Tab to see the XSplit overlay, then hit "Stream" to begin sending your video to Twitch. XSplit automatically works out the optimal bitrate, based on your network connection. Switch away from your game, and XSplit displays a default BRB message to your viewers—this is a limitation of the free version, so if it bugs you, you should think about upgrading.

3 HARDWARE TIMES

Quit your game for now (this stops the streaming automatically), and head back to the Gamecaster interface, so we can make sure it's using the correct hardware to do its thing



[Image B]. In "Settings/Devices," use the drop-down box to ensure it's using the correct microphone for your headset—we wouldn't recommend using, say, a laptop mic, just for the sake of those watching—and check that your webcam is hooked up, too. You should see a preview in the top-left of the window if it is. You can also tweak the audio levels that go out to your stream here—although, because these settings are also available through the XSplit overlay, you may be better altering them there, based on the feedback of your viewers.

4 ADD YOUR CAMERA

What would game streaming be if your viewers couldn't see the look on your face as you get destroyed for the 32nd time? It would be rubbish. Thankfully, Gamecaster makes adding a camera to your stream a trivial matter. Go back to your game (you don't have to resume streaming just yet), hit Ctrl-Tab to bring up the overlay, and click on the camera icon to plop your webcam on top of your game. Now drag the edges to resize it, and drag the center to place it where you want it, trying not to cover up anything important. It can be tough to play games with the self-conscious feedback loop caused by staring at your own face, but you can choose to have the cam only appear to stream viewers, thankfully. Hover your mouse over the bar on the edge of the webcam [Image C] and find the visibility icon, then switch off "In Game HUD" to have it only appear to stream viewers.

5 KEEP UP WITH CHAT

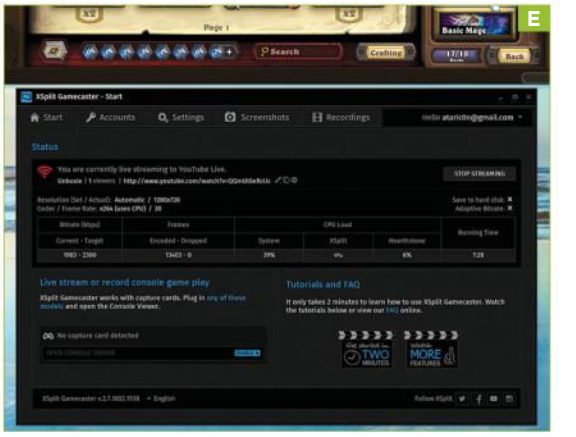
Let us flip the principle we just used to hide the webcam while playing, in order to introduce a layer that only we can see. Twitch chat, 30-second delay or not, is a vital part of staying connected to your audience, and if you're running full-screen, or don't have the luxury of multiple monitors, Gamecaster's chat overlay is vital. Open the overlay with Ctrl-Tab, hover over the Twitch icon, and click the second icon down to show the Twitch chat panel. Find the visibility icon, and this time set it to only display on the in-game HUD. It's also worth dropping the opacity of the window somewhat (take it all the way to zero to only see the chat messages), and repositioning it so it's not covering vital areas of gameplay [**Image D**]. If you want to send messages while you're playing, just open up the overlay as usual, and type into the gray box at the bottom of the chat window. Finishing your message with Shift-Enter closes the overlay automatically when you've finished typing.

6 STREAMING PROPER

By now, you'll have your layout locked down. Just a couple of things to do: set the title of your stream, and tell people you're online. Hover over the Twitch icon, and hit the cog to customize your title—XSplit will have automatically matched up the game you're playing with a game in Twitch's extensive database. The next icon along enables you to share to Facebook and Twitter—click each icon to authorize your account, as you did with your Twitch account earlier on, then hit "Share" to send the message out.

7 MOVING HOME

Provided your YouTube account is in good standing, you can stream your gameplay via YouTube Live instead of Twitch. Head back to the Gamecaster app, go to the "Accounts" tab, and click the drop-down arrow to the right of your Twitch account. Select



"YouTube Live," and authorize the account as before. You may need to accept YouTube Live's terms of service before you can complete this step; Gamecaster gives you a link if that's the case. When you begin streaming, enter your stream info into the box provided—you can't change this on the fly as with Twitch—and be sure to change the status from "Unlisted" to "Public" if you want your channel's subscribers to see that you're streaming.

8 SEE YOUR STATUS

While streaming, keep half an eye on the "Start" tab of the Gamecaster window. It keeps you informed of your current bitrate, any dropped frames, and the load on your system from your game, XSplit, and overall [**Image E**]. If these numbers creep too high, you may need to drop your bitrate manually by going to "Settings," clicking the "Automatic" box next to "Streaming," selecting "Custom," and dialing in your own options. Happy streaming!

THE OBS ALTERNATIVE

While XSplit hides many of its features behind its subscription fees, Open Broadcaster Software (www.obsproject.com) is a free, open source way to get your footage streaming online. It's less user-friendly than Gamecaster, and there's a reason the majority of streamers favor XSplit, but OBS might be a good move before stumping up the cash. It structures itself into scenes and sources, which you need to create before you can start streaming. A single scene can contain multiple sources—images, games, webcams—and setting up multiple scenes before streaming means you can transition smoothly between them. Grab OBS Studio for the most up-to-date version; it's still in development, but it works just fine.

Fix Audio Issues in Windows 10

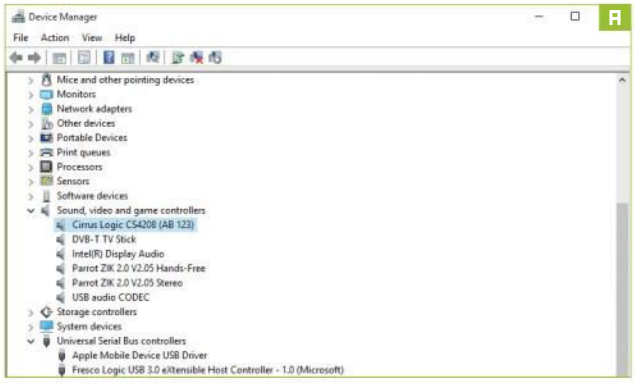
YOU'LL NEED THIS

WINDOWS 10
All these steps can be followed within the OS itself.

FOR ALL THE BENEFITS that come with upgrading to Windows 10, there have been reports that some people have experienced problems with sound output, leaving them unable to enjoy movies or hear anything at all from their PC's speakers.

For example, users whose PCs have VIA HD Audio have found they can only hear sound from certain apps. Fortunately, there's a workaround if you're affected by this issue. Right-click "Playback Devices," right-click the audio output device, and set it as the default device. Then select the device with your left mouse button, choose "Properties," select the "Enhancements" tab, and check "Disable all enhancements." That should fix the problem.

For everyone else with audio issues, try the following steps. You'd be surprised at how effective they can be. –TIM HARDWICK

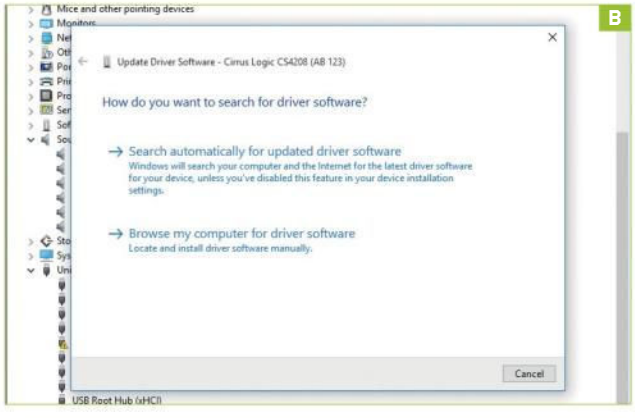


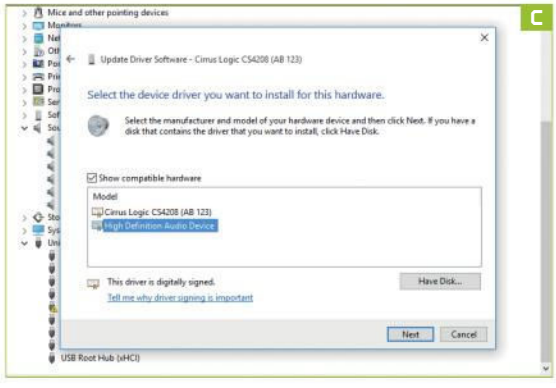
1 DRIVER ISSUES

The most common sound problems are due to users not updating the device driver for their PC's soundcard or audio chip. Open the "Start" menu, and type "Device Manager." Launch the utility by clicking it, and you'll see a list of icon options. Choose "Sound, video, and game controllers" [**Image A**]. If your PC has a soundcard, you'll see it here. Click the card profile to open it.

2 UPDATE DRIVER

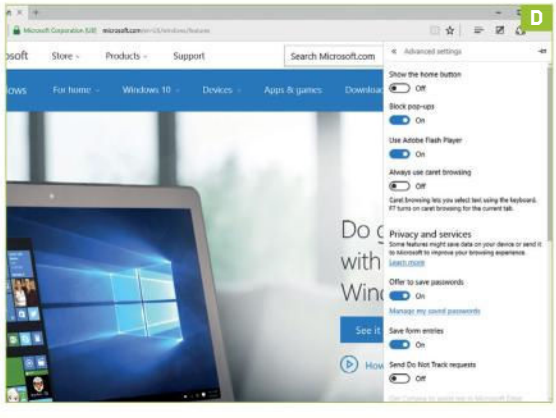
Next, click the "Driver" tab and look for the option to "Update Driver" [**Image B**]. Select it, and Windows starts to search for the correct driver online, then downloads it. If the search comes up empty, visit your soundcard manufacturer's website to find the applicable driver to download. Once the driver update is complete, restart your PC, and check whether the issue has been resolved.

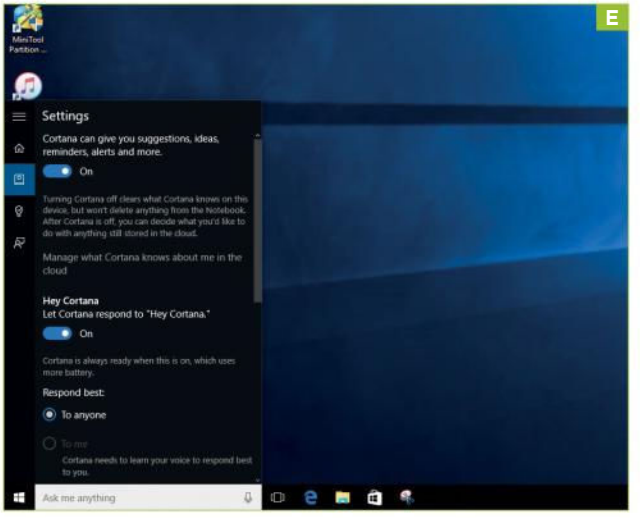

B
Update Driver Software - Cirrus Logic CS4208 (AB 123)
How do you want to search for driver software?
Search automatically for updated driver software
Windows will search your computer and the Internet for the latest driver software for your device, unless you've disabled this feature in your device installation settings.
Browse my computer for driver software
Locate and install driver software manually.
Cancel
USB Root Hub (xHCI)


C
Update Driver Software - Cirrus Logic CS4208 (AB 123)
Select the device driver you want to install for this hardware.
Select the manufacturer and model of your hardware device and then click Next. If you have a disk that contains the driver that you want to install, click Have Disk.
Show compatible hardware
Model
Cirrus Logic CS4208 (AB 123)
High Definition Audio Device
This driver is digitally signed.
Tell me why driver signing is important
Have Disk...
Next
Cancel
USB Root Hub (xHCI)

3 GENERIC DRIVER

If updating your soundcard driver fails to fix the problem, try Windows' generic audio driver. Open Device Manager, right-click your soundcard, and choose "Update driver software." Choose "Browse my computer for driver software," then select "Let me pick from a list of device drivers on my computer." Click "High Definition Audio Device" from the list [**Image C**], click "Install," and restart your PC.





4 BROWSER ISSUES

If your sound issue is restricted to not being able to hear sound online when using Edge, it could be a problem with Adobe Flash Player. Open the Edge browser, and you'll see a button in the top corner of the window, with three dots in it. Click this, select "Settings," then "Advanced Settings" at the bottom of the list. Ensure the toggle is on next to "Adobe Flash Player" [Image D].

5 CORTANA WON'T LISTEN

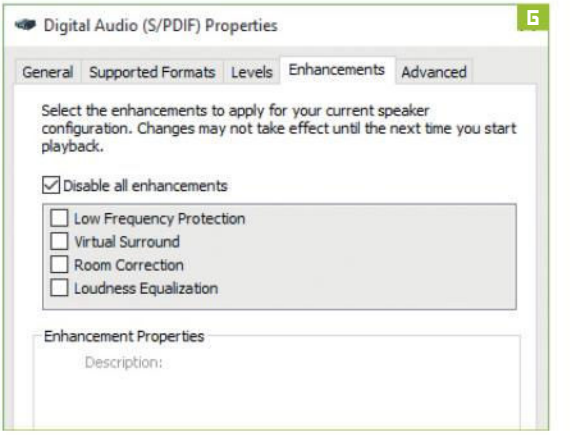
When enabled, Microsoft's voice assistant, Cortana, is meant to listen to your commands upon hearing the words "Hey, Cortana." If it isn't hearing you, make sure your PC's microphone is on. Also, check the settings—open Cortana, select the Notebook icon, and then "Settings." Make sure the option for Cortana to listen for "Hey, Cortana" is turned on [Image E].

6 CHECK CABLES

Check your speaker and headphone ports for loose cables or the wrong jack, and flex the wires to see whether there's a poor connection. Also, check your power, and try turning the volume controls up. Some speakers and apps have their own volume controls, so you might have to check them all. Remember, your speakers are probably set to go off when your headphones are plugged in.

7 SET DEFAULT DEVICE

If you're connecting to an audio device using USB or HDMI, you might need to set that device as the default before you hear anything. To do so, open the "Start" menu, type "Sound" into the search box, and select it from the list of "Settings" results. Next, click the "Playback" tab, select the device you're trying to connect, and click "Set Default" [Image F]. If this doesn't work, connect the device to another port.



8 BAD ENHANCEMENTS

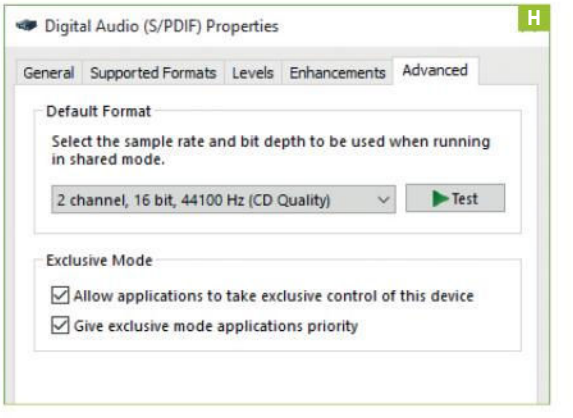
Occasionally, the issue can lie with the audio enhancements that Microsoft or third parties have designed. Happily, you can turn them off. Open "Start," type "Sound" into the search box, and select "Sound Control Panel" from the list of "Settings" results. Select the "Playback" tab, right-click the "Default Device," and choose "Properties." On the "Enhancements" tab, check "Disable all enhancements" [Image G].

9 CHANGE AUDIO FORMAT

Sometimes, incompatible drivers or third-party audio software can affect playback, so check if an audio format is the source of your problem. In the "Sound" control panel, select "Playback," right-click the "Default Device," and choose "Properties." Select "Advanced," and change the setting under "Default Format" [Image H], then retest your audio. If that doesn't work, try another format.

10 TROUBLESHOOTER

If all other efforts fail to solve the problem, try Windows 10's native audio troubleshooter. Occasionally, it can resolve an issue you're having. To run it, open "Start," type "troubleshooting" into the search box, and select it from the "Settings" results. Then, under "Hardware and Sound," click "Troubleshoot audio playback," and click "Next" in the window that appears.



Make a Pi MusicBox AirPlay Receiver

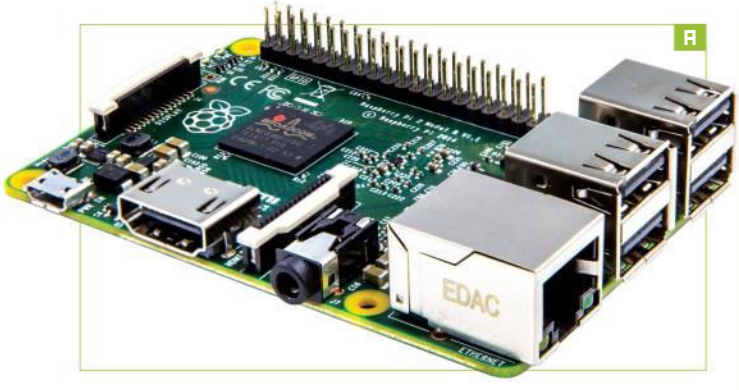
YOU'LL NEED THIS

RASPBERRY Pi 2
The brilliant mini-computer costs under $45. See www.raspberrypi.org.

Pi MUSICBOX
Go to http://bit.ly/MopidyPiMusicBoxAnswers for a whole heap of help.

AIRPLAY REMAINS a great way of wirelessly piping music through your home, but even basic AirPlay speakers come with a hefty price tag attached. In many cases, you'll already have a perfectly serviceable stereo system in place, so why spend a fortune on another speaker (or pair of speakers), when you can put together your own wireless AirPlay receiver for around $65? Better still, why limit yourself to AirPlay, when your receiver can do so much more?

We were inspired to try this project by a desire to make full use of a 25-year-old Pioneer stereo system that sounds as good as the day we bought it. We had reasonable hopes the receiver would make good use of the stereo's sound capabilities, but even we couldn't have foreseen just how spectacular the results would be. –NICK PEERS



1 GETTING STARTED

This project will cost you around $65 for all the parts, and there is some soldering involved, but the good news is that, once complete, you'll have a full-blown music receiver that can do much more than act as an AirPlay receiver.

›› Your AirPlay receiver will consist of a number of components, and you're free to trade up or down as you see fit. We picked the Pi Zero because it's so cheap, but you can easily adapt this project to the Raspberry Pi 2 [**Image A**]. (The current version of Pi MusicBox isn't compatible with the Pi 3, but it can be made to work—head to http://bit.ly/MopidyPiMusicBoxAnswers for information on this and other issues.) Doing so may cost more, but you avoid the need to do any soldering, and you even have the option of turning your AirPlay receiver [**Image B**] into a standalone system—you just need some speakers. (Fancy building a full-blown AirPlay stereo system? Pair a full-size Raspberry Pi with the Pi-DigiAMP+ ($82) and Pi-CASE+ ($22) from www.iqaudio.com, along with a 15V power brick ($35) from www.modmypi.com, and all you need to supply are speakers.)

2 GRAB THE GEAR

If you're following our project, however, you need the Pi Zero ($5), then you need to go to www.thepihut.com to purchase the Essential Raspberry Pi Zero Kit ($8, for the adapters and GPIO header), a USB Wi-Fi dongle ($11), and Pi Zero power adaptor ($8). Visit www.iqaudio.com to purchase the Pi-DACZero ($21), which offers twin phono outputs to hook up to your stereo.

›› You'll want a case for your receiver, and IQ Audio sells its own dedicated case for $15, which will push the cost of your receiver up, but if you don't mind the Pi-DACZero sitting on top of your case, you'll find a range of alternative cases online. Finally, you need a class 10 microSD card, which only needs to be 1GB in size, although if you plan to store music on the Pi Zero, you'll want it to be 16GB or bigger. Shop around to limit your cost to $7, then visit the Audio & Video section of Lindy (www.lindy.com) if you need a suitable cable (about $4).

3 SOLDERING ON

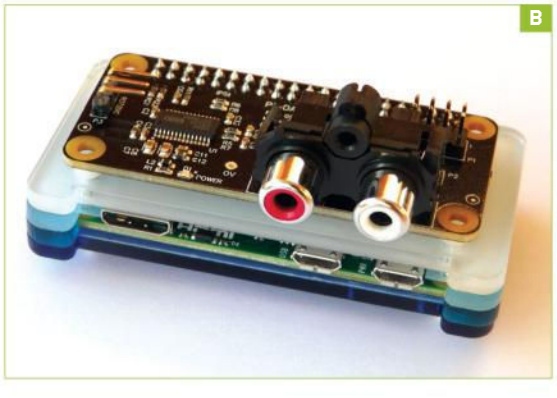
The biggest task you face with the Pi Zero is soldering the GPIO header on [**Image C**]—this is required to connect up the DAC. If you're just starting out, check your local hardware store for a soldering iron, stand, suitable solder, and tub of flux—it should all come to about $15.

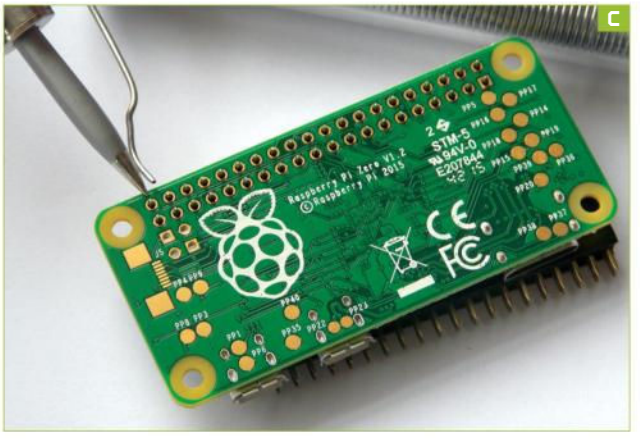
›› Make sure the Pi Zero is the right way up, and insert the male header into the correct holes at the back of the board, with the shortest pins facing down. If you turn the Pi Zero over, you should see the pins protrude above the board, which is where you'll solder them into place. Use something to prop up the board while you apply the solder.

›› Place the soldering iron in the stand, dampen the cloth on the stand, switch on the iron, and wait for it to heat up. While waiting, dip the end of the solder wire into the flux, as this helps prevent it from sticking. When the soldering iron is hot enough, dip its tip into the flux, too.

4 GET STUCK IN

Now place the tip against one of the corner pins. Introduce the solder to it, wait for a bit to melt off, and fix the pin in place. Now repeat for the pin in the opposite corner. At this point, switch off the iron and wait a




C

few seconds for the Pi Zero to cool down. Pick it up and turn it over to verify the solder has taken, and the pins remain straight.

» Flip the Pi Zero over again, and solder the other 38 pins [**Image D**]. Remember to clean the soldering iron tip on the damp pad every now and then, plus keep adding flux to prevent sticking. There's a handy online video for soldering on the GPIO header at https://youtu.be/MSGIrtGMYRM that we strongly recommend you watch.

» If you purchase a Pibow case—as we originally did—you'll find it seals off the slot to the micro SD card. This isn't a deal-breaker, but you will need to insert the card into your Pi Zero and test it before constructing the case. To do so, follow the first three steps of the walkthrough (pg. 98) to prepare your microSD card with Pi MusicBox. At time of writing, the latest version (0.6) isn't compatible with the Pi Zero, but we found a modified build that works perfectly—this is the version you download in the walkthrough—or visit www.pimusicbox.com to see if a newer, compatible version is ready.

» Once your microSD card is ready, insert it, attach the Wi-Fi adapter, and switch the Pi Zero on. You don't need a keyboard or monitor, as Pi MusicBox can work headless, which enables you to access it remotely using any web browser [**Image E**] or via SSH (see "Access via SSH," pg. 96). Go to http://musicbox.local to do so.

5 FINAL CONNECTIONS

Once you've verified everything's working correctly, click "System," and choose "Shutdown" to power off the Pi Zero. Disconnect all cables, leave the microSD card in place, then assemble the Pibow case if you're using it. Once you plug the Pi-DACZero into the Pi Zero's GPIO header, it should fit securely.

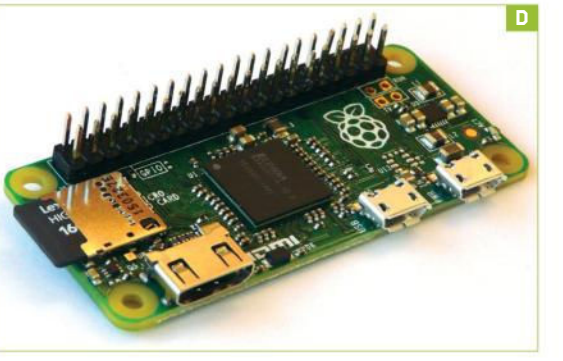
» You can now power the Pi Zero back on, and follow the final two steps of the walkthrough (see pg. 98) to finish the basic configuration. Connect the Pi-DACZero to your stereo, set the correct input, then test the connection using an app or program that supports AirPlay. When selecting an AirPlay device, you should see "MusicBox" is listed—select this, and enjoy your music full-blast through your stereo.

6 ADDING SERVICES

Now you've got your AirPlay music receiver up and running, it's time to see what else you can do with it. First, let's examine what other streaming services Pi MusicBox supports. Go to http://musicbox.local/settings and expand the "MusicBox" section. You'll see a switch that enables support for streaming from your DLNA/uPNP/OpenHome media server. Flick this switch on and look for "MusicBox" as a streaming option when playing music from your server. For example, Emby users will see "MusicBox—DLNA" appear as a playback device under "Select Player," via the Emby web interface, enabling you to send music to it direct from the server.

» Pi MusicBox also enables you to connect your receiver to a number of different online services, including Spotify (Premium users only), SoundCloud, YouTube (audio only), and Last.fm—just follow the instructions to connect them, typically by flicking a switch, adding the requisite token, or by providing your user account details. You'll have to reboot Pi MusicBox each time you save your settings, so consider adding multiple accounts at once to save time. Once you've connected to a service, you'll be able to access it via the "Browse" section of the web interface.

» You can stream podcasts and radio through your receiver, too, by selecting "Browse → TuneIn → Local Radio," to see if your favorite station is covered. Failing that, go to "Streams," where you can connect sources

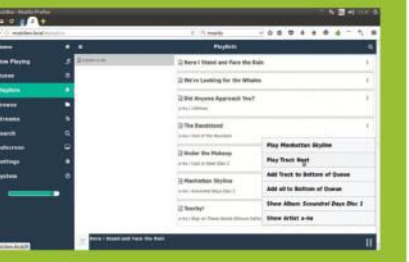

D

PLAYLIST SUPPORT

While Pi MusicBox is capable of playing M3U playlists, there is—as yet—no means of actually creating and managing them within the server. Thankfully, playlist creation is built into various supported clients, including both mobile apps and web-based front ends.

One of the best apps we've found for this job is Mopidy Mobile on Android, but you'll need to connect it to Pi MusicBox manually using your Pi Zero's IP address (get this via SSH using `ifconfig` if necessary). Once done, you'll not only have complete control over your Pi Zero, but you can set up playlists relatively easily, too: Click the "Edit" button (the pencil icon), followed by the "Create" button, give your playlist a suitable name, and tap "Save," then "Done."

Next, switch to the Library section, browse for a track to add, tap the "Menu" button next to it, and choose "Add to playlist." Tap your playlist, then repeat for other tracks. You can't remove tracks



from the playlist, or edit the running order with Mopidy Mobile, so choose with care. Once created, the playlist is available everywhere—including the main Pi MusicBox web interface.

that provide compatible streams in MP3, M3U, ASX, and similar formats. Simply enter the URL into the box, and click "Play" to listen. If it works, you can also provide a name, and click "Save" for future access. A number of streams are set up by way of example—you can try these, or clear them to provide room for your own.

7 STORE MUSIC LOCALLY

Pi MusicBox can also play music stored locally, either on its own internal microSD card, or via a FAT-formatted USB drive, although the latter necessitates the use of a hub for your Pi Zero. You'll need to choose the Broadcom Hub and Wi-Fi Adapter from www.pi-supply.com instead of the Wi-Fi adapter when building your Pi Zero. It costs about $14.

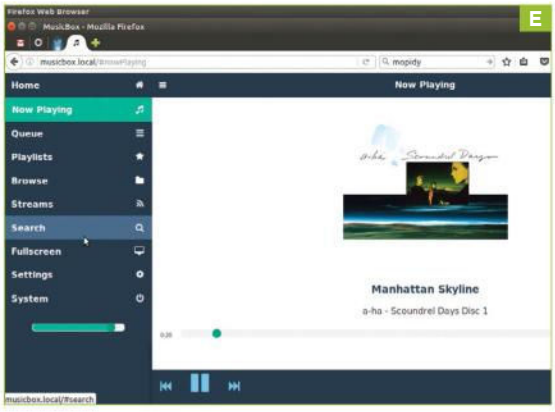
» There are two good reasons for using local storage. First, if your Wi-Fi signal isn't particularly strong, you may find streaming problematic, whereas locally stored media plays fine, so long as the connection is good enough to receive commands. Second, Pi MusicBox supports a wide number of audio formats, including the audiophile-preferred lossless FLAC format. If quality is important, and you don't mind each album consuming around 300–400MB of space, FLAC really is the best way to listen to your music.

» If you've not yet ripped your CDs, you'll find most ripping tools support FLAC, albeit not by default. If you're a Rhythmbox user, for example, you need to select "Edit → Preferences → Music tab" to pick it as your preferred format. If quality isn't as important, however, the default Ogg Vorbis format is supported by Pi MusicBox, as are MP3 and AAC, all of which enable you to store more albums on your card or USB drive.

» If you plan to store music on the microSD card, make sure it's large enough (16GB minimum, but 64GB or more is recommended). You first need to instruct Pi MusicBox to make all that extra space available. To do this, from the web interface, choose "Settings → Music Files." Flick the "Resize filesystem" switch to "On," and reboot. Once done, return to "Music Files," and make sure "Scan Music Files" is switched to "On" whenever you add new music to the card or a USB drive.

8 TRANSFER YOUR MUSIC

Once you've ripped your music to your PC, transferring it to your Pi MusicBox is done one of two ways: If your network connection is strong, the quickest and most convenient way is to open your file manager and browse for "MusicBox.local" over your network. You'll find a shared Music folder, inside which you copy your files using the traditional artist/album/track hierarchy. Alternatively, power down your Pi Zero, and connect the microSD



card direct to your system. You'll find two partitions are mounted—select "RPI0," browse to "Music\MusicBox," and copy your music into here.

» Pi MusicBox is based on the Mopidy music server, which provides support for services through custom-written extensions. At the time of writing, Pi MusicBox hadn't been updated for about a year. In the meantime, Mopidy has received a number of major updates, while Pi MusicBox's underlying Raspbian installation is based on the old "Wheezy" release. The author has revealed he's working on a new Jessie-based version that should not only be officially compatible with the Pi Zero (and Pi 3), but should also update Mopidy to a later version.

» One benefit of running the latest version of Mopidy is that it's an extremely versatile beast, and if you take a trip to https://docs.mopidy.com, you'll see a large section dedicated to Extensions, where you'll find more ways to expand your music receiver. One particular bonus is the ability to swap out the default web client for something more attractive. A number of alternatives have been developed, but while it's tempting to try them with your current installation, don't—doing so will upgrade Mopidy to 2.0, which will break your system. Instead, check out the guide to installing Raspbian Jessie and Mopidy 2.0 from scratch. If you're impatient to try the latest version of Mopidy, you can build your own custom installation using Jessie Lite as the back end. A full guide can be found at http://mopidy.readthedocs.org—expand "Installation," and select "Raspberry Pi" for a step-by-step guide.

ACCESS VIA SSH

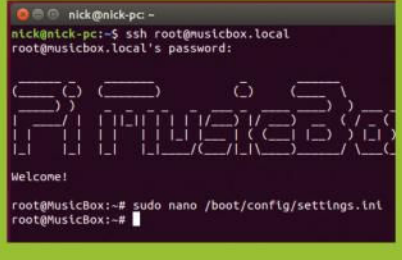
Should you want to access the underlying operating system behind Pi MusicBox, you can do so via SSH. First, enable SSH in Pi MusicBox via "Settings" under "Network." We also recommend changing the default password ("PiMusicBox"), which can be done from the MusicBox section. Click "Update settings (reboot)," and once Pi MusicBox is up and running again, open Terminal on your PC, and set up an SSH connection with the following command: `ssh root@musicbox.local`. Type `yes` when prompted, then enter the root password.

Once you've logged in, you can access the PiMusicBox configuration file by using the following command:

```
sudo nano /boot/config/settings.ini
```

Here you can quickly tweak the same settings you see via the web interface. Note: The file itself is stored in plain text for all to see, hence the importance of changing the root password.

You can also use the command line to update the underlying OS—we don't recommend it, unless necessary, as it's been known to break Pi MusicBox—plus install additional packages, if required.



You could, for example, follow the guide at http://bit.ly/MusicBoxToBluetooth to see if you can add Bluetooth support to Pi MusicBox. You can also access Pi MusicBox's underlying operating system through SSH, but be warned, it'll expose its underlying insecurities.

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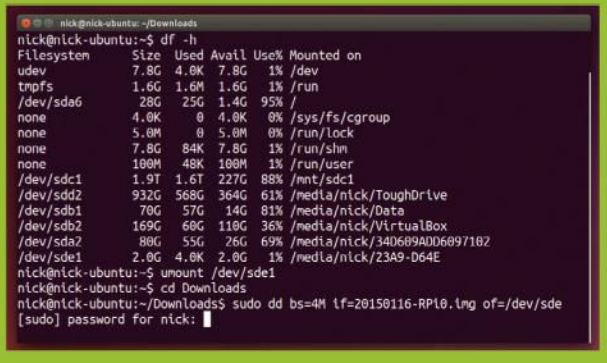
SET UP PI MUSICBOX

1. PREPARE YOUR MICROSD CARD

Connect a microSD card to your PC via a USB adapter. If you get an error about exFAT, you need to format it as FAT32. Open Disks from the Dash, and select your card. You'll see an exFAT partition—select it and click "-" to delete it. Click "+" and set the partition size to 2048MB, choose "FAT," and click "Create."

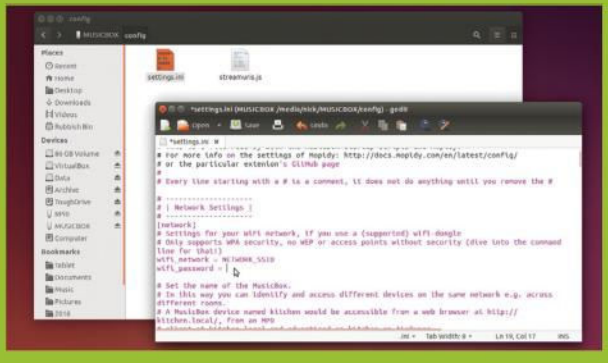
2. DOWNLOAD PI MUSICBOX

You need a specially built Pi Zero-friendly build of Pi MusicBox—download the 350MB image from http://bit.ly/pimusiczero. Once saved to your Downloads folder, open Nautilus, browse to the folder, right-click "20150116-RPi0.zip," and choose "Extract Here." Now open a Terminal window, and enter `df -h`.


nick@nick-ubuntu: ~/Downloads
nick@nick-ubuntu:~$ df -h
Filesystem Size Used Avail Use% Mounted on
udev 7.8G 4.0K 7.8G 1% /dev
tmpfs 1.6G 1.6M 1.6G 1% /run
/dev/sda6 28G 25G 1.4G 95% /
none 4.0K 0 4.0K 0% /sys/fs/cgroup
none 5.0M 0 5.0M 0% /run/lock
none 7.8G 84K 7.8G 1% /run/shm
none 100M 48K 100M 1% /run/user
/dev/sdc1 1.9T 1.6T 227G 88% /mnt/sdc1
/dev/sdd2 932G 568G 364G 61% /media/nick/ToughDrive
/dev/sdb1 70G 57G 14G 81% /media/nick/Data
/dev/sdb2 169G 60G 110G 36% /media/nick/VirtualBox
/dev/sda2 80G 55G 26G 69% /media/nick/34D689ADD6897102
/dev/sde1 2.0G 4.0K 2.0G 1% /media/nick/23A9-D64E
nick@nick-ubuntu:~$ umount /dev/sde1
nick@nick-ubuntu:~$ cd Downloads
nick@nick-ubuntu:~/Downloads$ sudo dd bs=4M if=20150116-RPi0.img of=/dev/sde
[sudo] password for nick:

3. WRITE PI MUSICBOX IMAGE

Identify your card's 2GB partition ("/dev/sde1" in our example), and type `umount /dev/sde1` to unmount it. Type `cd Downloads`, then the following (substitute "/dev/sde" with the mount point for your card): `sudo dd bs=4M if=20150116-RPi0.img of=/dev/sde`. Wait for the image to be written.

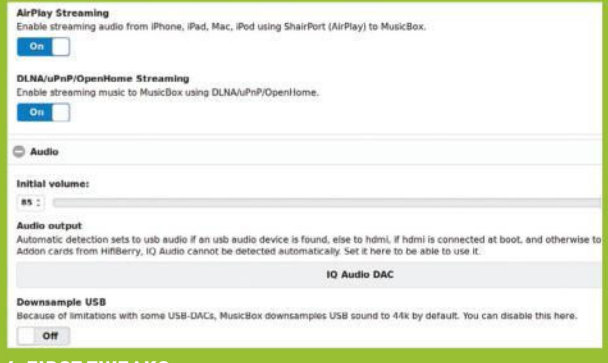


4. ADD WI-FI DETAILS

Unplug the USB adapter, then plug it back in. Two windows open, pointing at different partitions. Open the "config" folder under "MUSICBOX," and double-click "settings.ini." Find the [network] section, and add your Wi-Fi network's SSID to `wifi_network=`. Type your network password next to `wifi_password=`.

5. BOOT AND TEST

Select "Save," exit the text editor, and click "Eject," before unplugging the USB adapter. Insert the microSD card into your Pi Zero, and switch on. A flashing green light indicates it's booting correctly. Wait a few minutes, open your browser, and type "http://musicbox.local" into the URL navigation field.


AirPlay Streaming
Enable streaming audio from iPhone, iPad, Mac, iPod using ShairPort (AirPlay) to MusicBox.
On
DLNA/uPnP/OpenHome Streaming
Enable streaming music to MusicBox using DLNA/uPnP/OpenHome.
On
Audio
Initial volume:
85
Audio output
Automatic detection sets to usb audio if an usb audio device is found, else to hdmi, if hdmi is connected at boot, and otherwise to
Addon cards from HifiBerry, IQ Audio cannot be detected automatically. Set it here to be able to use it.
IQ Audio DAC
Downsample USB
Because of limitations with some USB-DACs, MusicBox downsamples USB sound to 44k by default. You can disable this here.
Off

6. FIRST TWEAKS

Go to "Settings → Audio," click the "HDMI" menu, and choose "IQ Audio DAC." Turn "Downsample USB" off. Expand the MusicBox section, and turn "Airplay Streaming" on. Scroll to the bottom, and click "Update settings (reboot)." Once booted, connect the Pi DAC Zero to your stereo's auxiliary input. You're ready to stream!

Future

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